

AD A086471

DDC FILE COPY

MONITORING THE USE OF RIVERWAYS WITH AERIAL PHOTOGRAPHY

THIS DOCUMENT IS BEST QUALITY PRACTICABLE.
THE COPY [illegible] CONTAINED A
SIGNIFICANT [illegible] PAGES WHICH DO NOT
REPRODUCE LEGIBLY.

DTIC
ELECTE
JUL 14 1980
S D
C

This document has been approved for public release and sale; its distribution is unlimited.

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

Final

of a report to the

Great River Environmental Action Team (GREAT II)

and the

Rock Island District, U.S. Army Corps of Engineers

entitled:

MONITORING THE USE OF RIVERWAYS WITH AERIAL PHOTOGRAPHY: THE DEVELOPMENT, TESTING, AND EVALUATION OF A COMPUTER ASSISTED METHODOLOGY.

DTIC
ELECTE
JAN 14 1980

by

Wisconsin Water Resources Center

and

Department of Landscape Architecture
School of Natural Resources
College of Agricultural and Life Sciences
University of Wisconsin-Madison

Under Contract Number: DACW25-79-C-0008

Mar[redacted]80
University of Wisconsin-Madison 53706

This document has been approved for public release and sale; its distribution is unlimited.

AUTHORS

CO-INVESTIGATORS

William A. Gates

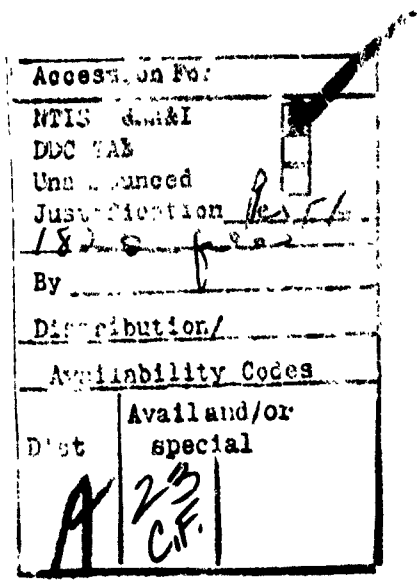
Bernard J. Niemann, Jr.

RESEARCH ASSISTANTS

Kenneth M. Foyil

Gregory L. Mills

James A. Morton



PROJECT PARTICIPANTS -

Principal Investigators

R.H. Becker
W.A. Gates
B.J. Niemann, Jr.

Gordon Chesters, Director, Wisconsin Water Resources Center
Stephen Smith, Associate Dean, College of Agricultural and Life Sciences - School of Natural Resources

RESEARCH ASSISTANTS

Susan Cedarleaf
Ken Foyil
Terry Iliff
Ken Kailing
Greg Mills
Andy Morton
Fred Townsend

UNDERGRADUATE STUDENT ASSISTANTS

Jim Tokuhisa
Jon Miller
Tom Shaffer
Jan Cyr
Del Siebert

ACKNOWLEDGEMENTS

The investigators wish to acknowledge several individuals for their assistance. Bob Patenaude and Jim Scherz, the pilots, for their careful and timely flying. Sue Cedarleaf for general assistance during the project. Ken Foyil for designing the camera mount, obtaining all the photography, managing all the film acquisition and processing, developing the hand/code-book, interpreting the film and assisting in the drafting of this report. Greg Mills for writing some of the software and conducting the data transfer, establishing statistical runs, running color xerox, and assisting in report preparation. Andy Morton for developing some of the software, entering the flight data, assisting in the development of the hand/code-book, designing and fabricating the stereoscope mount, interpreting the photography and assisting in the drafting of the report. Sue Coyne for typing this report and doing her usual excellent job. Paddi Millard for also assisting in the report typing.

William A. Gates
Bernard J. Niemann, Jr.
March 31, 1980

TABLE OF CONTENTS

	Page
COVER	
TITLE PAGE	
AUTHORS	
PROJECT PARTICIPANTS	
ACKNOWLEDGEMENTS	
TABLE OF CONTENTS - SECTION 1	1-2
LIST OF FIGURES AND TABLES	1-3
INTRODUCTION	1-4
OBJECTIVES	1-4
REPORT ORGANIZATION	1-4
STUDY AREA	1-5
METHODS EMPLOYED	1-5
TABLE OF CONTENTS - SECTION 2	2-2
LIST OF PHOTOGRAPHS, FIGURES AND TABLES	2-3
POOL 16 USER RESULTS	2-5
POOL 16 CHARACTERISTICS	2-5
TARGET EXAMPLES	2-5
POOL 16 TARGET FREQUENCIES	2-6
Combined Frequencies	2-6
Separate Frequencies	2-6
POOL 16 WATERCRAFT DISTRIBUTIONS	2-6
General Distributions	2-6
Beaching Distributions	2-7
Hunting Blind Distributions	2-7
Targets in Relation to Specific River Mile Locations	2-7
ROCK ISLAND MARINA	2-8
RAMPING ESTIMATE FOR JULY 4	2-8
SUMMARY	2-9

	Page
TABLE OF CONTENTS - SECTION 3	3-2
LIST OF TABLES	3-3
EVALUATION OF METHODOLOGY	3-4
PERSONNEL AND EQUIPMENT REQUIREMENTS	3-4
TIME REQUIREMENTS	3-4
Time Requirements for All Pools	3-4
Time Requirements for Pool 16	3-5
Conclusions in Respect to Time	3-5
COSTS	3-6
Costs for Aerial Photography for All Pools	3-7
Cost for Data Entry and Analysis	3-7
Cost Per Target	3-7
Conclusions in Respect to Cost	3-7
RELIABILITY	3-8
Negative Factors Affecting Reliability and Useability of Aerial Photographic Acquisition	3-8
Camera System Failure	3-8
Flight Planning and Execution Failure	3-8
Negative Factors Affecting Reliability and Useability of Aerial Photographic Target Interpretation	3-8
Target Encoding Error	3-8
Mis-coding Values	3-9
Film Handling Errors	3-9
Positive Factors for Acquiring Aerial Photography (Recommendations)	3-9
Positive Factors in Improving Reliability and Useability of Aerial Photographic Target Interpretation	3-9
Handbook Development	3-9
ORION System and Software	3-10
Zoom Stereoscope/Talos Digitizer/ORION System	3-10
ERROR ESTIMATES	3-12
Error Examples	3-12
Target Confusion and Confidence Measures	3-13
Docks	3-14
June 21 Reliability Test	3-16

	Page
TABLE OF CONTENTS - SECTION 4	4-2
LIST OF PHOTOGRAPHS, FIGURES AND TABLES	4-4
REQUIREMENTS FOR AERIAL PHOTOGRAPHY	4-5
LOGISTICAL REQUIREMENTS	4-5
Personnel requirements	4-5
Pilot	4-5
Photographer	4-5
Aerial photography manager	4-6
Equipment requirements	4-6
Aircraft	4-6
Photographic system	4-7
Camera mount	4-7
Drawing/drafting system	4-8
Film storage	4-8
Film viewing	4-8
Dark Bag	4-8
Supply requirements	4-9
Photographic film	4-9
Aerial exposure computer	4-9
Base maps for flight planning	4-10
Film packaging and shipping materials	4-10
Coastal and Geodetic Survey sectional charts	4-10
Miscellaneous drawing/drafting/filing supplies	4-10
Services requirements	4-10
Photomechanical and engineering services	4-10
Weather forecasting and flight services information	4-11
Film processing	4-11
Contractual acquisition of aerial photography	4-11
Physical space requirements	4-12
ACQUISITION OF AERIAL PHOTOGRAPHY	4-12
Photographic scale	4-12
Format	4-13
Tilt	4-14
Flight maps	4-15
Selection of base maps	4-15
Use of flight maps	4-15
Layout of flight maps	4-16
Updating and revision of base maps	4-17

	Page
Timing of the aerial photographic mission	4-17
Time of year	4-17
Time of week	4-18
Time of day	4-18
Personnel constraints	4-19
Flexibility	4-19
Preparation for the aerial photographic mission	4-19
Photographic system	4-19
Film and film loading	4-20
Flight maps and flight logs	4-20
Aircraft	4-21
Weather and atmospheric condition compatability	4-21
Personnel comfort	4-21
Execution of the aerial photographic mission	4-22
Film magazine unloading/reloading and film labeling	4-22
On-site atmospheric conditions	4-22
Maintaining the flight log	4-23
Photographer/pilot communication	4-24
Supplementary (unplanned) photography	4-24
Contingencies	4-25
Film processing	4-25
MANAGEMENT OF PROCESSED AERIAL PHOTOGRAPHY	4-25
Imagery accession system	4-26
Imagery storage and retrieval	4-26
Imagery screening	4-27
Conformance with flight log	4-27
Frame number annotation	4-27
Imagery utility	4-27
APPENDIX 4.A	4-68
APPENDIX 4.B	4-75
TABLE OF CONTENTS - SECTION 5	5-2
LIST OF PHOTOGRAPHS AND FIGURES	5-3
REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING	5-4
OVERVIEW OF AERIAL PHOTOGRAPHIC INTERPRETATION	5-4

	Page
Personnel	5-4
Computer Programming	5-4
Airphoto Interpretation	5-4
Data Encoding	5-5
Equipment	5-5
Dedicated Microcomputer	5-5
Digitizer	5-5
Film Viewing System	5-6
Additional Supplies	5-6
Space	5-7
INTERPRETATIVE PROCESSING OF AERIAL PHOTOGRAPHY	5-7
Data Entry and Software Development	5-8
Handbook	5-8
Description of Records	5-8
Flight Line Information	5-8
Target Information	5-9
Ground Control Points	5-10
Writing Records into Storage	5-10
Text Editor	5-10
Display Program	5-11
APPENDIX 5.A	5-21
APPENDIX 5.B	5-26
APPENDIX 5.C	5-30
SECTION 6 - AERIAL PHOTOGRAPHIC INTERPRETATION HANDBOOK	

SECTION 1.
INTRODUCTION

TABLE OF CONTENTS - SECTION 1

	Page
INTRODUCTION	1-4
OBJECTIVES	1-4
REPORT ORGANIZATION	1-4
STUDY AREA	1-5
METHODS EMPLOYED	1-5

LIST OF FIGURES AND TABLES

Figures

			Page
1-1.	Upper Mississippi River Monitoring Study (Pools 11-22)	1-6	1-6

Tables

1-1.	Computer Output Books	1-7
1-2.	Aerial Photographic Record by Date, Pool and Time	1-8

INTRODUCTION

OBJECTIVES

The objectives of this investigation were to develop, test and evaluate a recreational monitoring methodology using aerial photography and computer assisted data capture with auxiliary equipment. To meet these objectives, photography was flown, interpretation techniques were developed and utilized, hardware was assembled, software was written and recreational monitoring results were obtained. Section 1

REPORT ORGANIZATION

This report is organized into six sections. Section 1, Introduction, includes a statement of objectives, how the report is organized, a summary of available photography, a brief summary of methods employed, and some conclusions. Section 2, Pool 16 User Results, includes the results obtained from applying the methodology for six flights over Pool 16. It also includes discussion of the results and provides graphic examples of results. Section 3, Evaluation of the Methodology, includes equipment and personnel requirements, the time utilized developing and testing the methodology, and the costs incurred. The reliability of the methodology, error control and error discovery are discussed. Section 4, Aerial Photographic Methods, includes a detailed discussion of the methods and equipment employed to purchase, obtain and process the aerial photography for the riverway. Section 5, Interpretative Methods, discusses the methods employed to interpret, locate and encode targets from the photography. Section 6, Handbook/Codebook, includes a detailed description of each variable encoded as part of the methodology. It also includes the rules used to interpret each of the target types.

In addition to the report itself, eight Computer Output Books are provided (see Table 1-1). These books include combined and separate frequencies, distribution of targets, interpreter confidence results and computer software developed and utilized as part of the methodology.

Within each section of the report are contained the relevant photographs, figures and tables. Given the diversity of material covered, it will be necessary to review various portions selectively and simultaneously. For example, to fully understand the Results section, it will be necessary to review the target names in the Handbook/Codebook, or to fully understand the Evaluation section, it will be necessary to become familiar with the Aerial Photographic Methods and Interpretive Methods.

STUDY AREA

All methods developed and employed were applied to pool 16. Aerial photography was obtained for pools 11-22 during the spring, summer and fall of 1979 (May 26 - October 28) (see Figure 1-1). Aerial photography coverage consists of 51 pool flights taken with oblique 70mm color and color infrared film and 12 pools with 9" x 9" color infrared film (see Table 1-1). Six dates from pool 16 were utilized to test and evaluate the methodology. They are Wednesday, June 21, Thursday, July 4, Saturday, August 11, Sunday, August 12, Wednesday, August 15, and Saturday, Sept. 15.

METHODS EMPLOYED

Various methods and techniques were tested and employed. Two basic forms of aerial photography were utilized. Two 70mm motor driven cameras were utilized to obtain oblique photography of the riverway. In addition, a 9" x 9" mapping camera was utilized to obtain photography. To assist in interpreting features seen as watercraft types (targets), a zoom stereoscope was utilized to enlarge the targets for the purposes of interpretation. A Handbook/Codebook was developed to provide consistent interpretation and encoding rules. Various features were initially included but dropped due to non-interpretability. A back-lighted XY digitizer was utilized to record and spatially locate each target. A mini-computing system (ORION) was utilized to interactively encode target values, check values, prompt interpreters and pre-process data for analysis. Main frame computing was utilized to analyze data and provide computer graphic results.

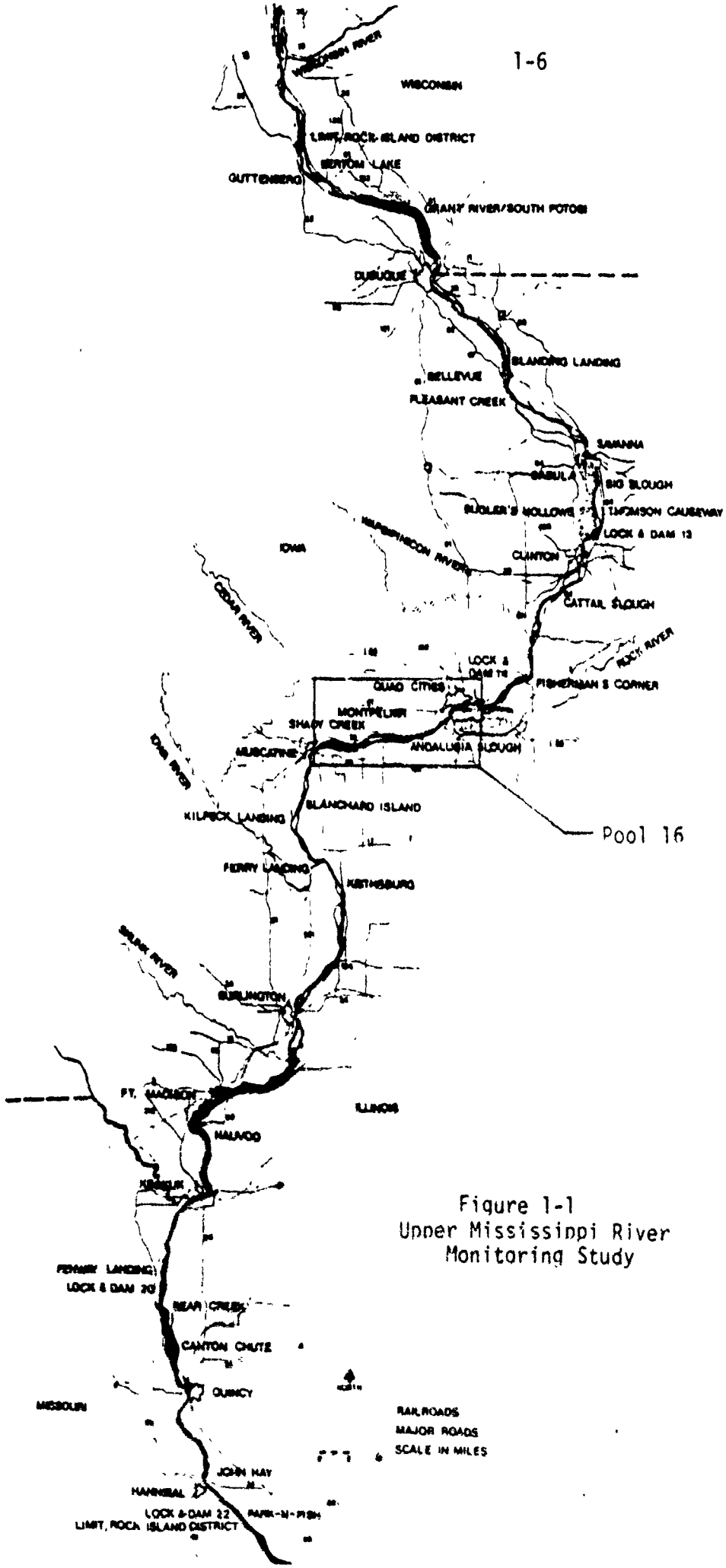


Figure 1-1
Upper Mississippi River
Monitoring Study

TABLE 1-1 Computer Output Books

BOOK NUMBER		
Book 1	Pool 16	Separate Frequencies Part 1. Frequencies for Pool 16 (River Mile 480 Marina Excluded) Part 2. Frequencies for Pool 16 (At River Mile 480)
Book 2	Pool 16	Combined Frequencies Part 1. Combined Frequencies for Pool 16 (River Mile 480 Marina Excluded) Part 2. Combined Frequencies for Pool 16 (At River Mile 480)
Book 3	Pool 16	Spatial Distribution of Targets by Channel, Activity, Mode of Use, Beached Craft Distribution, Undeveloped Beaching Sited by Date, Craft in Use by Dates
Book 4	Pool 16	Target Distribution for Specific Flights - Craft and Duck Blinds
Book 5	Pool 16	Confidence Interpretation Crosstabs Part 1. Confidence Crosstabs - All Flights Combined (River Mile 480 Marina Excluded) Part 2. Confidence Crosstabs - All Flights Combined (At River Mile 480)
Book 6	Pool 16	Confidence Film/Altitude Crosstabs Part 1. Confidence Crosstabs of Film Type by Target at Different Altitudes (River Mile 480 Marina Excluded) Part 2. Confidence Crosstabs of Film Type by Target at Different Altitudes (River Mile 480 Marina Excluded)
Book 7	Pool 16	River Mile by Dock Crosstabs Part 1. Partially Imaged Flights Part 2. Fully Imaged Flights
Book 8		ORION Software

TABLE 1-2. Aerial Photography Record (1979) by Pool, Date and Time of Day

Pool	Date	Daywk		Holiday Period	Time of Day	No. of Rolls	No. of Flt. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
		Wend	Wday						
11	Aug 11	x			0910-0925	9 x 9	3	18	-
11	Sep 8	x			1440-1520	4	10	142	3500
11	Oct 27	x			1105-1155	4	10	158	3500
12	Aug 11	x			0940-0950	9 x 9	3	14	-
12	Sep 8	x			1210-1240	2	8	108	3500
12	Oct 27	x			1200-1230	2	10	102	3500
13	May 26	x		x	1025-1140	6	12	274	2500
13	Jun 21		x		1010-1105	4	10	140	3500
13	Jul 4		x	x	1127-1225	4	10	144	3500
13	Aug 11	x			1000-1035	9 x 9	3	24	-
13	Aug 11	x			1415-1525	6	12	260	2500
13	Aug 15		x		1645-1755	6	12	258	2500
13	Sep 2	x		x	1435-1525	4	10	148	3500
13	Sep 8	x			1110-1205	4	10	146	3500
13	Sep 15	x			1325-1425	6	12	252	2500
13	Oct 27	x			1425-1510	4	10	146	3500
14	Aug 11	x			1035-1050	9 x 9	5	15	-
14	Aug 25	x			1805-1835	2	10	100	3500
14	Sep 8	x			1025-1100	2	10	102	3500
14	Oct 27	x			1515-1550	2	10	112	3500
15	Aug 11	x			1050-1055	9 x 9	2	7	-
15	Aug 25	x			1750-1800	2	4	34	3500
15	Oct 27	x			1725-1735	2	4	38	3500
16	May 28		x	x	0920-0955 1220-1310	6	14	216	2500
16*	Jun 21		x		1130-1425	2	6	110	3500
16*	Jul 4		x	x	1550-1615	2	6	116	3500
16*	Aug 11	x			1055-1110	9 x 9	4	11	-
16*	Aug 12	x			1500-1540	4	10	202	2500

TABLE 1-2. Aerial Photography Record (1979) by Pool, Date and Time of Day (continued)

Pool	Date	Daywk		Holiday Period	Time of Day	No. of Rolls	No. of Flt. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
		Wend	Wday						
16*	Aug 15		x		1420-1500	4	10	208	2500
16	Sep 2	x		x	0955-1020	2	6	116	3500
16	Sep 8	x			0955-1025	2	6	110	3500
16*	Sep 15	x			1450-1535	4	10	206	2500
16	Oct 27	x			1735-1800	2	6	112	3500
17	Jul 4		x	x	1455-1525	2	8	110	3500
17	Jul 29	x			1455-1525	2	8	122	2500
17	Aug 11	x			1110-1120	9 x 9	3	8	-
17	Aug 11	x			1605-1635	2	8	124	2500
17	Aug 15		x		1155-1220	2	8	122	2500
17	Aug 25	x			1715-1745	2	8	112	3500
17	Sep 2	x		x	1330-1410	2	8	118	3500
17	Oct 28	x			1610-1640	2	8	112	3500
18	Aug 11	x			1120-1130	9 x 9	4	10	-
18	Aug 25	x			1445-1525	2	10	128	3500
18	Oct 28	x			1445-1525	2	10	130	3500
19	Aug 11	x			1130-1150	9 x 9	7	23	-
19	Aug 25	x			1335-1445	4	22	204	3500
19	Oct 28	x			1340-1445	4	22	224	3500
20	Aug 11	x			1150-1200	9 x 9	2	8	-
20	Aug 25	x			1120-1135	2	4	62	3500
20	Oct 28	x			1200-1215	2	4	64	3500
21	May 28		x	x	1350-1500	4	8	208	2500
21	Jun 21		x		1355-1500	2	6	104	3500
21	Jul 29	x			1600-1640	4	8	202	2500
21	Aug 11	x			1200-1205	9 x 9	2	7	-
21	Aug 12	x			1217-1255	4	8	204	2500
21	Aug 15		x		1025-1105	4	8	198	2500
21	Aug 25	x			1050-1115	2	6	114	3500

TABLE 1-2. Aerial Photography Record (1979) by Pool, Date and Time of Day (continued)

Pool	Date	Daywk		Holiday Period	Time of Day	No. of Rolls	No. of Fli. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
		Wend	Wday						
21	Sep 2	x		x	1115-1145	2	6	110	3500
21	Sep 15	x			1720-1755	4	8	200	2500
21	Oct 28	x			1130-1200	2	6	110	3500
22	Aug 11	x			1205-1220	9 x 9	5	13	-
22	Aug 25	x			1025-1050	2	8	76	3500
22	Oct 28	x			1105-1130	2	8	80	3500

Notes:

1. Both 70mm and 9" x 9" imagery entries are included.
2. Flight altitudes are reflected for 70mm imagery only.
3. All 9" x 9" imagery flown on August 11, 1979.
4. Total number of 70mm pool flights: 51.
5. Total number of 70mm rolls: 156.
6. Total number of 70mm flight lines (flight map x 2): 456.
7. Total number of 70mm exposures (in-flight log x 2): 7294.
8. Total number of 9" x 9" exposures: 158.
9. Flight time over pool approximated by the time of day entry.
10. Time of day expressed in terms of 24 hour clock.
11. Pool 16 flight dates marked with an asterisk (*) were those selected for interpretation.
12. May 28 flight over pool 16 had non-continuous coverage - the delay from 0955 to 1220 a result of trouble-shooting camera system.

SECTION 2.

POOL 16 USER RESULTS

TABLE OF CONTENTS - SECTION 2

	Page
POOL 16 USER RESULTS	2-5
POOL 16 CHARACTERISTICS	2-5
TARGET EXAMPLES	2-5
POOL 16 TARGET FREQUENCIES	2-6
Combined Frequencies	2-6
Separate Frequencies	2-6
POOL 16 WATERCRAFT DISTRIBUTIONS	2-6
General Distributions	2-6
Beaching Distributions	2-7
Hunting Blind Distributions	2-7
Targets in Relation to Specific River Mile Locations	2-7
ROCK ISLAND MARINA	2-8
RAMPING ESTIMATE FOR JULY 4	2-8
SUMMARY	2-9

LIST OF PHOTOGRAPHS, FIGURES AND TABLES

Photographs

		Page
2-1.	Pool 16 RM 457-461, 11 August 79 9" x 9" Flight.	2-10
2-2.	Pool 16 RM 459-463, 11 August 79 9" x 9" Flight.	2-11
2-3.	Pool 16 RM 461-465, 11 August 79 9" x 9" Flight.	2-12
2-4.	Pool 16 RM 463.5-467.5, 11 August 79 9" x 9" Flight.	2-13
2-5.	Pool 16 RM 466-470, 11 August 79 9" x 9" Flight.	2-14
2-6.	Pool 16 RM 468-472, 11 August 79 9" x 9" Flight.	2-15
2-7.	Pool 16 RM 471-475, 11 August 79 9" x 9" Flight.	2-16
2-8.	Pool 16 RM 473.5-477.5, 11 August 79 9" x 9" Flight.	2-17
2-9.	Pool 16 RM 476-480, 11 August 79 9" x 9" Flight.	2-18
2-10.	Pool 16 RM 478.5-483, 11 August 79 9" x 9" Flight.	2-19
2-11.	Pool 16 RM 481.5-485.5, 11 August 79 9" x 9" Flight.	2-20
2-12.	Barge Tow Complex.	2-21
2-13.	Deck-Hull Motorcraft in Marina Complex.	2-22
2-14.	Open-Hull Motorcraft with Beaching Site.	2-23

Figures

2-1.	General Watercraft Activity Status.	2-24
2-2.	Watercraft Location by Channel.	2-25
2-3.	General Craft Distribution.	2-26
2-4.	Distribution of Craft in Use.	2-27
2-5.	Open-Hulled Motorcraft Distribution.	2-28
2-6.	Deck-Hulled Motorcraft Distribution.	2-29
2-7.	Houseboat Distribution.	2-30
2-8.	Barge and/or Tow Distribution.	2-31
2-9.	Undeveloped Beaching Sites - Dates of High User Density.	2-32
2-10.	Undeveloped Beaching Sites - Dates of Low User Density.	2-33
2-11.	Undeveloped Beaching Sites - Shoreline Location.	2-34
2-12.	Undeveloped Beaching Sites - Beach Cover.	2-35
2-13.	Hunting Blind Distribution.	2-36
2-14.	Craft Digitized from Section of Photograph 2-3. Shoreline Features Plotted Manually with Zoom Transfer Scope.	2-37
2-15.	Craft Digitized from Section of Photograph 2-7. Shoreline Features Plotted Manually with Zoom Transfer Scope.	2-38
2-16.	Craft Distribution - Rock Island Marina.	2-39
2-17.	Structure Distribution - Rock Island Marina.	2-40
2-18.	Target Classes Present - Rock Island Marina.	2-41

Tables

		Page
2-1.	Target Frequencies for Pool 16 (River Mile 480 Marina Excluded)	2-42
2-2.	Target Frequencies for Pool 16 (River Mile 480 Marina Excluded)	2-43
2-3.	Target Frequencies for Pool 16 for Three Dates (River Mile 480 Marina Excluded)	2-44
2-4.	Rock Island Marina and Empty Slip Data (Exclusive of Covered Docks)	2-46

POOL 16 USER RESULTS

This section of the report reviews the results for six flights of interpreted aerial photography for pool 16 during the spring, summer, and fall of 1979. Pool 16, for the purposes of this analysis, begins at river mile 457 and ends at 483.

The intention of this section is to present an array of results and examples. It will include various types of output plus various forms of output available as part of the methodology. Besides including the normal statistical type tables, graphic examples are included. If spatial encoding concepts had not been incorporated into the methodology, graphic output would have been limited if not impossible. To illustrate method flexibility, graphics are emphasized. More traditional frequency tables and crosstabs are provided in computer output books.

POOL 16 CHARACTERISTICS

Pool 16 consists of a variety of physical river features including adjacent urban development, large expanses of water, marinas, islands, sandbars, etc. Use of the riverway itself is diverse, ranging from large watercraft to waterfowl blinds. The development of the monitoring methodology consisted of determining the detectability of various riverway features including land and river targets (see Section 6 - Handbook for complete list and description of targets). The array of riverway features and some of the larger targets are observable in Photographs 2-1 through 2-11. These photographs are contact copies of the 9" x 9" color infrared film taken on August 11, 1979.

TARGET EXAMPLES

Actual aerial photographic interpreation methods are explained in detail elsewhere (see Sections 4 and 5). The process, in general, consisted of using an aerial photo magnification interpretative procedure and a digitizer, and a computer to determine, locate, and encode a target type. A target can be a canoe, barge, hunting blind, etc. Upon establishing the target type, additional interpretations are encoded for each target such as shoreline, mode of use, beaching status, etc.

The following photographs are not from pool 16 but illustrate target types. For example, Photograph 2-12 illustrates a barge-tow complex. The crosshair over the middle of the barge-tow complex is what the interpreter views during the interpretation process. Photograph 2-13 illustrates a marina complex and the watercraft being targeted is a deck-hull motorcraft. Photograph 2-14 illustrates two open-hull motorcraft underway. In addition, a non-vegetated beaching site is observable along the shoreline.

POOL 16 TARGET FREQUENCIES

Combined Frequencies

The six flights of pool 16 yielded 3673 targets. This consisted of interpreting 424 targets from June 21, 799 from July 4, 609 from August 11, 593 from August 12, 515 from August 15, and 733 from September 15.

Table 2-1 shows the overall distribution of target types for the six flights excluding the marina at river mile 480 (see Book 2, page 42). This river mile was excluded due to being partially imaged on August 12 and August 15. The dominant target was open-hulled motorcraft (1182). The next largest target was small uncovered docks (468). In respect to the distribution of various targets, the highest concentration of targets were located at river mile 473 which is a marina site (see Table 2-2).

From the interpretation perspective, each target flight represents a judgement. From a use monitoring perspective, counting the same dock on each separate flight may be considered double counting. As it turns out, however, docks are a more dynamic target than initially thought. For example, an analysis of data relating to small docks shows an increase over the summer. Inspection of the film shows small docks being added as late as the month of August. Some of the variation in docks is also due to interpreter error. This error was caused by too loose of a decision rule for small docks.

Separate Frequencies

Table 2-3 shows various target frequencies for three selected dates. June 21 is a weekday, July 4 is a holiday, and August 11 is a Saturday. Of the six flight dates, July 4 was the largest target date and June 21 was the smallest. On June 21, there were 47 watercraft beached, 45 in use; on July 4 there were 165 watercraft beached, 242 in use; and on August 11 there were 73 watercraft beached and 63 in use (see Book 1, Part 1 for other dates). These results show considerable use differences between various days of the week, time of year, and a holiday vs. a Saturday.

POOL 16 WATERCRAFT DISTRIBUTIONS

General Distributions

Figure 2-1 is a bar graph which illustrates the general watercraft activity status for watercraft types for six dates. This graph illustrates open-hull watercraft which are by far the most active watercraft type in pool 16. Figure 2-2, as another bar graph, illustrates that except for barge/tow (this is a composite variable including all barge targets), open-hull, decked-hull, and houseboats use all portions of the main, secondary and backbay portions of the riverway. Figure 2-3 illustrates the general distribution of the same four watercraft

types between river mile 457 and 483. In general, the four watercraft share use of the same river mile portions of the riverway. Spikes occur at a high use beaching site at river mile 462 and an existing marina at river mile 473. Figure 2-4 illustrates how this pattern of two peaks is modified when the four watercraft are plotted in use vs. river mile.

Figures 2-5 through 2-8 illustrate the prominent location of the four boat types in respect to channel location. There is considerable consistency in respect to channel location except for barge type watercraft.

Beaching Distributions

Since beaching is an important pool 16 activity, various graphs are provided to illustrate this phenomena. Figure 2-9 illustrates two high use days. Beach activity is quite intensive for pleasure craft at river mile 462 and 470. (Pleasure craft includes all watercraft from canoes through houseboats, codes 1-9). For example, there were approximately 60 watercraft targeted on July 4 and approximately 43 watercraft targeted on August 12 at river mile 462. River mile 462 is the obvious choice of most watercraft beach users in pool 16. Other sites are simply not as popular. Figure 2-10 illustrates the same general use pattern but during much lower use days. There does not appear to be any appreciable relational difference between beach site use during low use and high use days.

Figure 2-11 illustrates the use of beaching sites between those located on the main riverbank itself and those located on islands. The clear choice is to beach on islands vs. riverbanks. Figure 2-12 provides some additional information in respect to beaching adjacent to vegetated vs. non-vegetated sites. The clear consensus is for beaching activities to occur at non-vegetated or sand dominated sites. Combining this distribution with islands indicates quite clearly that pleasure craft users prefer islands with sand. In respect to river miles, they prefer river mile 462, 470 and 472.

Hunting Blind Distributions

Another target interpreted was duck blinds. This target was not in place during the beginning of flight periods. As the summer progressed, more duck blinds became evident. Figure 2-13 illustrates the distribution of duck blinds as targeted from the September 15 flight. On September 15, there were approximately 51 blinds between river mile 463 and 458.

Targets in Relation to Specific River Mile Locations

To illustrate additional graphic and analytical flexibility of the methodology, two additional examples are provided. Figure 2-14 and 2-15 illustrate specific portions of the riverway. These

illustrations were created by using the digitized input. Using computer plotting techniques, the actual target types are plotted in their original XY coordinate location. The riverway boundaries were added using the photographic image and a zoom transfer scope. In essence, the distribution of various watercraft targets can be plotted, located and identified within the entire pool or for selected areas as shown. This allows for specific geographic location and distribution of any target or any set of watercraft targets.

ROCK ISLAND MARINA

The Rock Island marina is treated separately to illustrate the full capabilities of spatial encoding and in order to portray its contribution to river use relative to private docks and ramping. The marina is fully imaged on June 21 (211 targets), July 4 (202 targets), August 11 (249 targets), and September 15 (224 targets). Photograph 2-9 images the marina near its top edge. Figure 2-16 illustrates a plotted blowup of the craft types digitized in the marina from the same 9" x 9" photography. Figure 2-17 is a similar blowup of the structures and estimated empty slips from the 9" x 9" photography.

Variation in the number of targets digitized was expected. The method of interpreting empty slips required judgement in estimating how many targets could actually be placed in an empty space along a dock. The number of slips, empty or otherwise, in covered docks was not estimated. An estimate of marina capacity, exclusive of covered docks, can be obtained by summing watercraft and empty slips and taking the average for the four dates. This average is 215. The average number of empty slips is 59 for the four dates. Basic data is provided in Table 2-4 and was derived from tables in Book 2, Part 2. Figure 2-18 is a histogram of target types for August 11; (the date 9" x 9" photography was flown).

RAMPING ESTIMATE FOR JULY 4TH

A conservative estimate of ramping assumes that all docks, large or small, covered or uncovered, contribute at least one watercraft to river use. There were 407 watercraft beached or in use (but not docked) on July 4th. Along the river there were 37 covered boat slips and 61 small uncovered docks, and only 5 empty slips. There were 76 empty slips counted in the Rock Island Marina. The total of watercraft from these sources is 179. Ignoring any contribution from the covered docks at the Rock Island Marina, this suggests 228 watercraft from ramping or more than one-half the total.

SUMMARY

This begins to illustrate the value of a methodology based on aerial photography and computer assisted data encoding. The array of use characteristics presented would be much diminished without the spatial accuracy provided by the digitizer, the magnification obtained from the zoom stereoscope and the reliability obtained by software control of the process. Of utmost importance is the ability to use aerial photography itself to perform reliability studies and thereby gain further insights into useful ways to represent the information collected. The statistical analysis when combined with capability to plot and display the same information dynamically as well as in correct spatial representation, is extremely valuable for understanding watercraft distributions within river mile segments.



Photograph 2-1 Pool 16, RM 457-461, 11 August 79 9" x 9" Flight

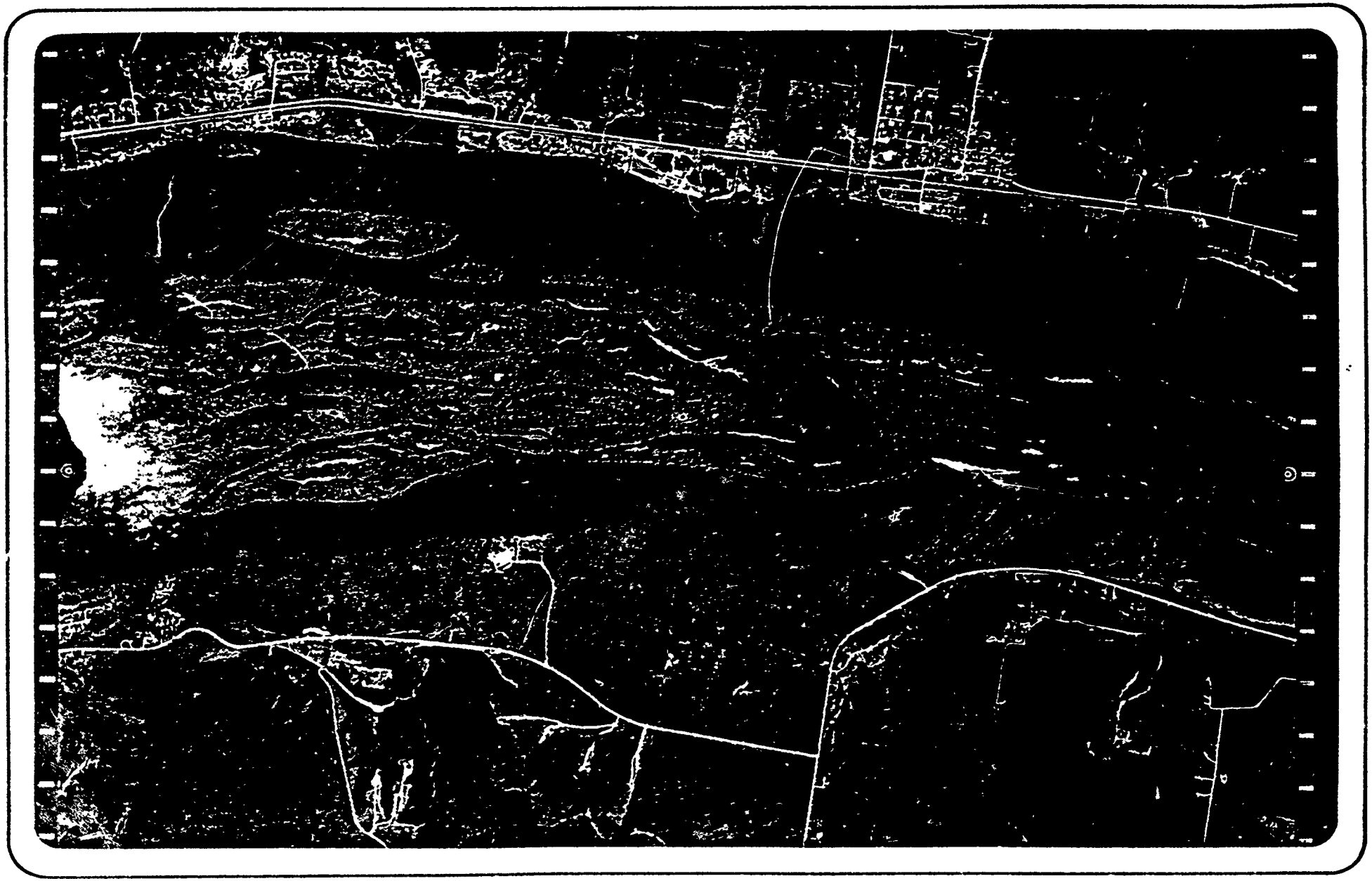
Photograph 2-2 Pool 16, RM 459-463, 11 August 79 9" x 9" Flight



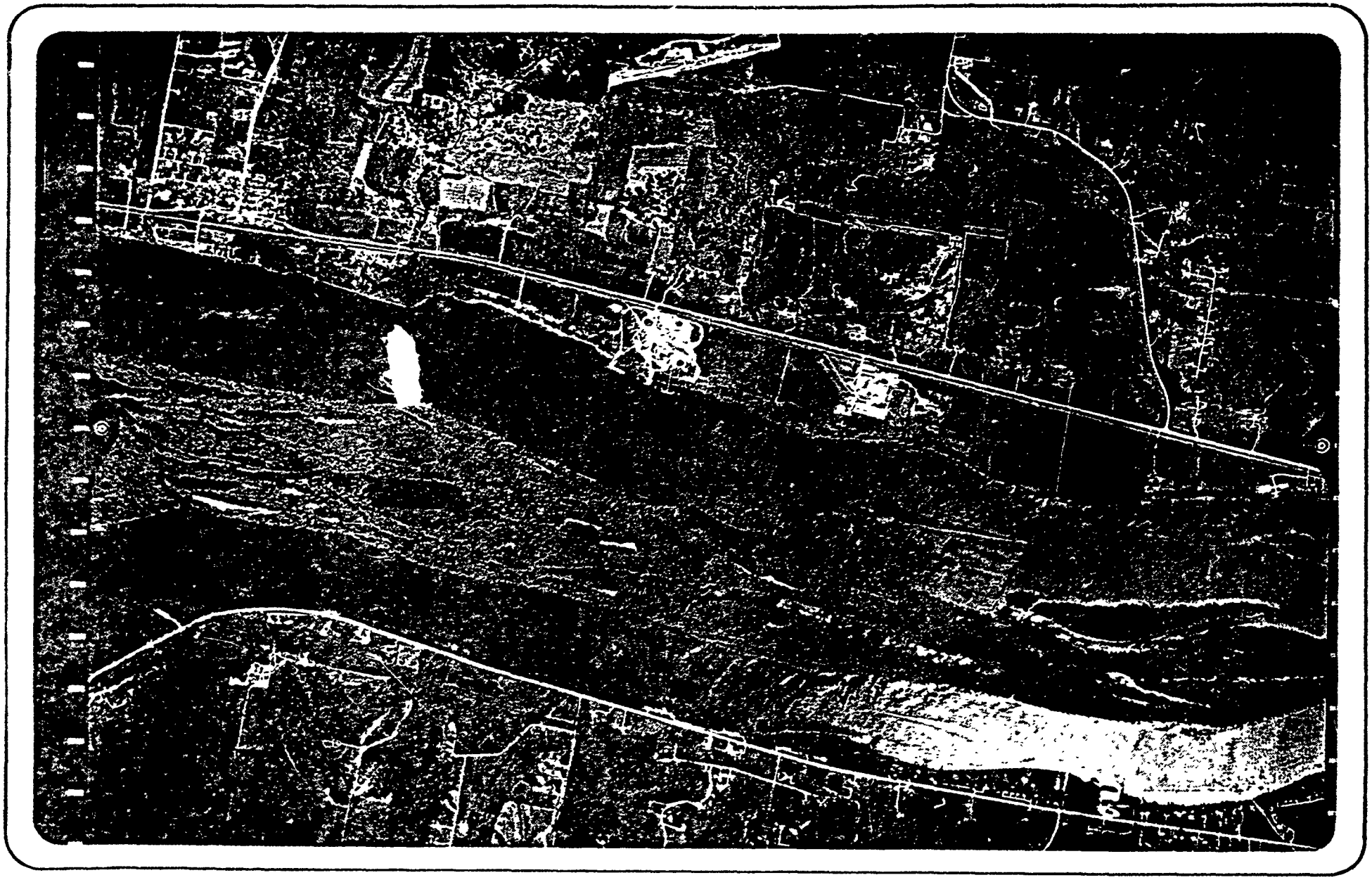
Phtoograph 2-3 Pool 16, RM 461-465, 11 August 79 9" x 9" Flight



Photograph 2-4 Pool 16, RM 463.5 - 467.5, 11 August 79 9" x 9" Flight



Photograph 2-5 Pool 16, RM 466- 470, 11 August 79 9" x 9" Flight



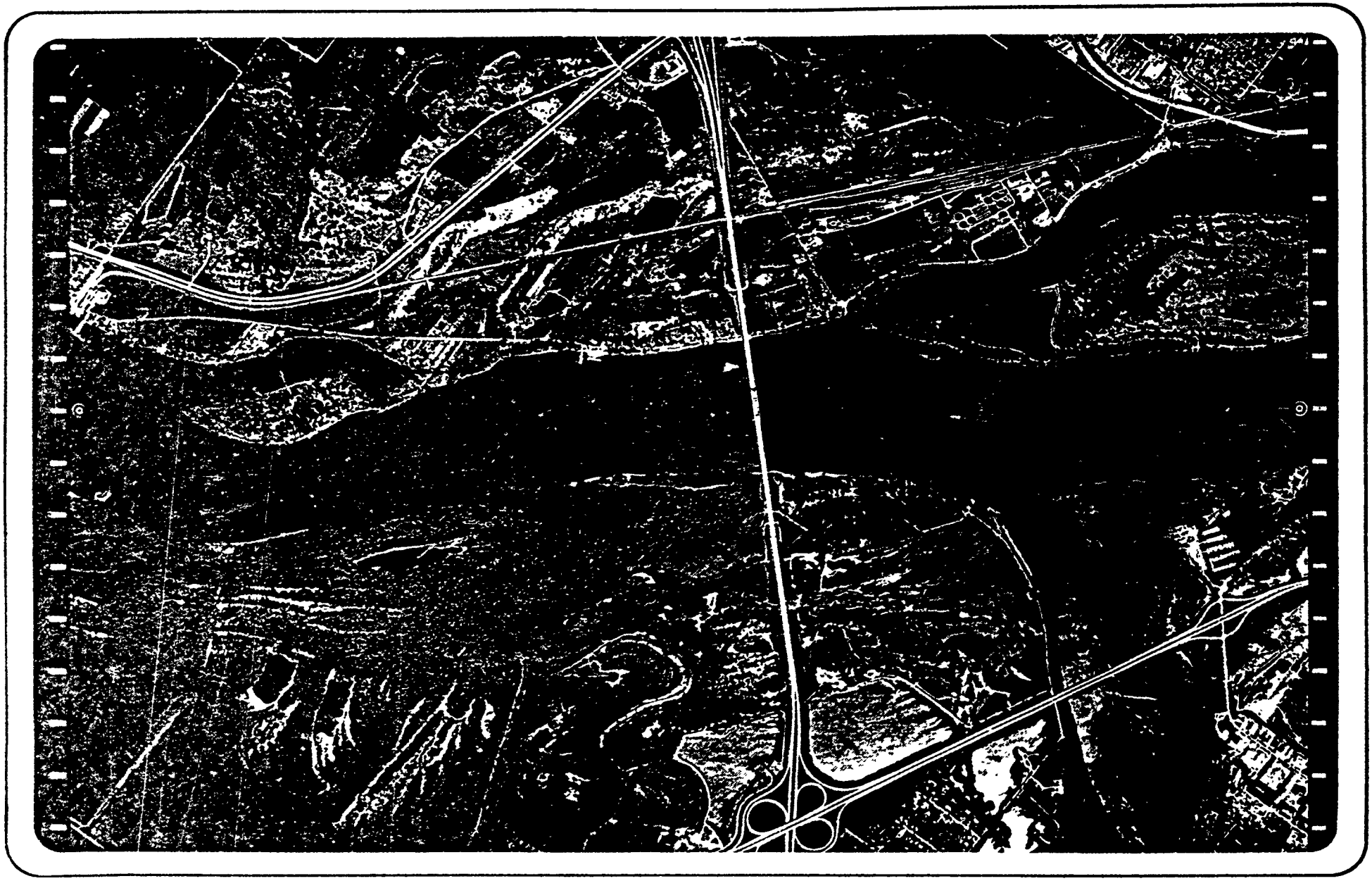
Photograph 2-6 Pool 16, RM 468 - 472, 11 August 79 9" x 9" Flight



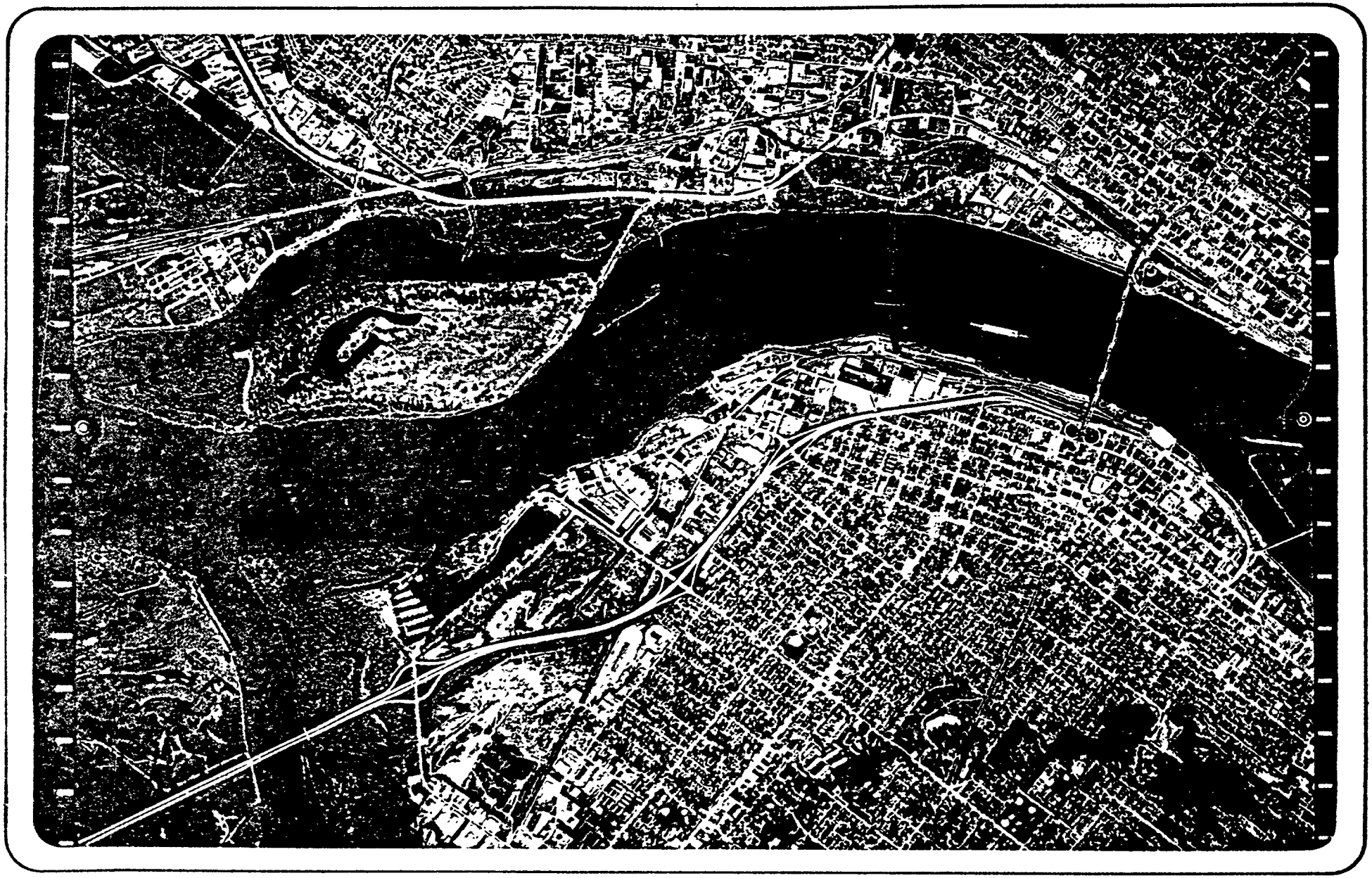
Photograph 2-7 Pool 16, RM 471 - 475, 11 August 79 9" x 9" Flight



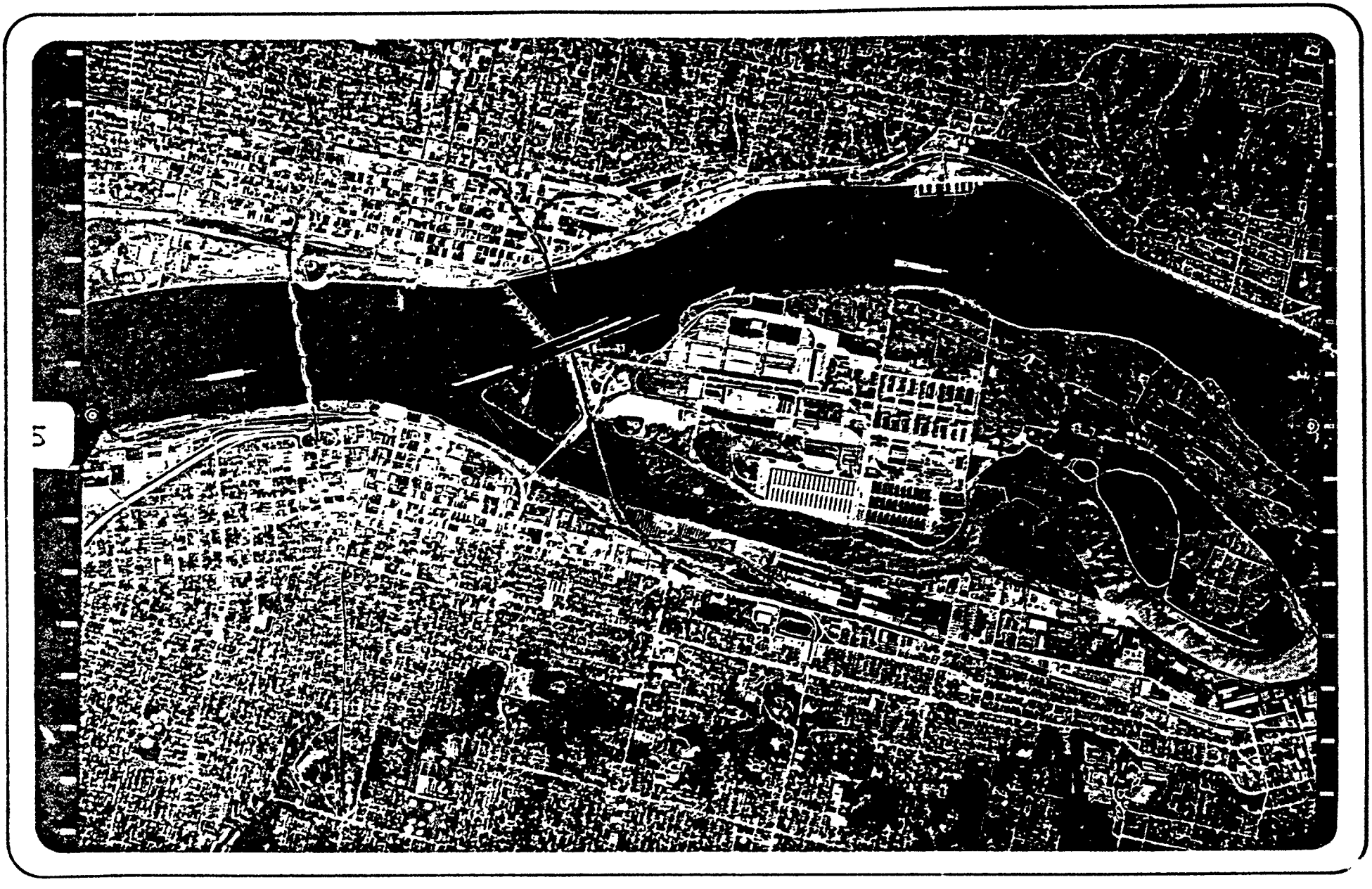
Photograph 2-8 Pool 16, RM 473.5 - 477.5, 11 August 79 9" x 9" Flight



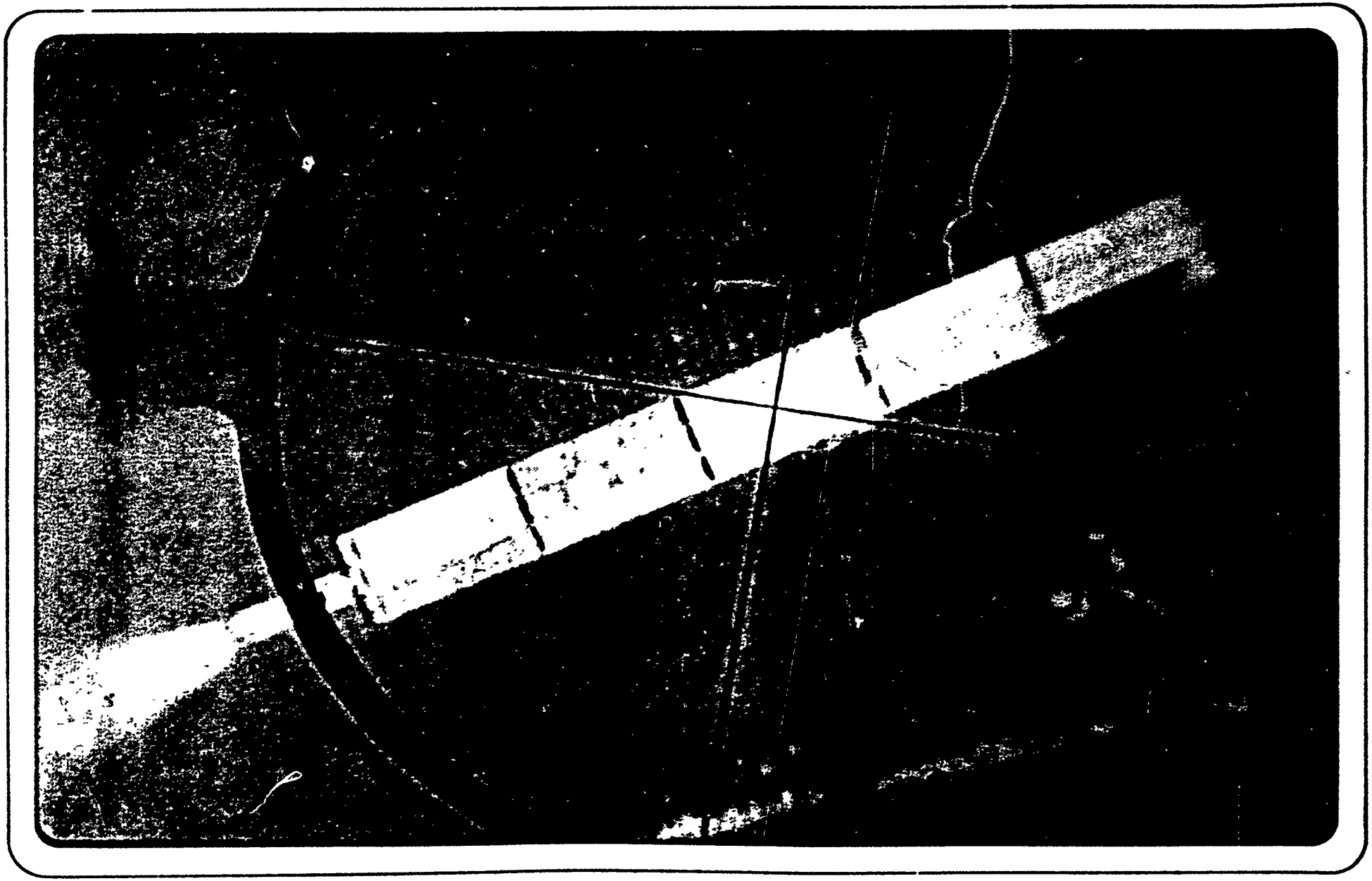
Photograph 2-9 Pool 16, RM 476 - 480, 11 August 79 9" x 9" Flight



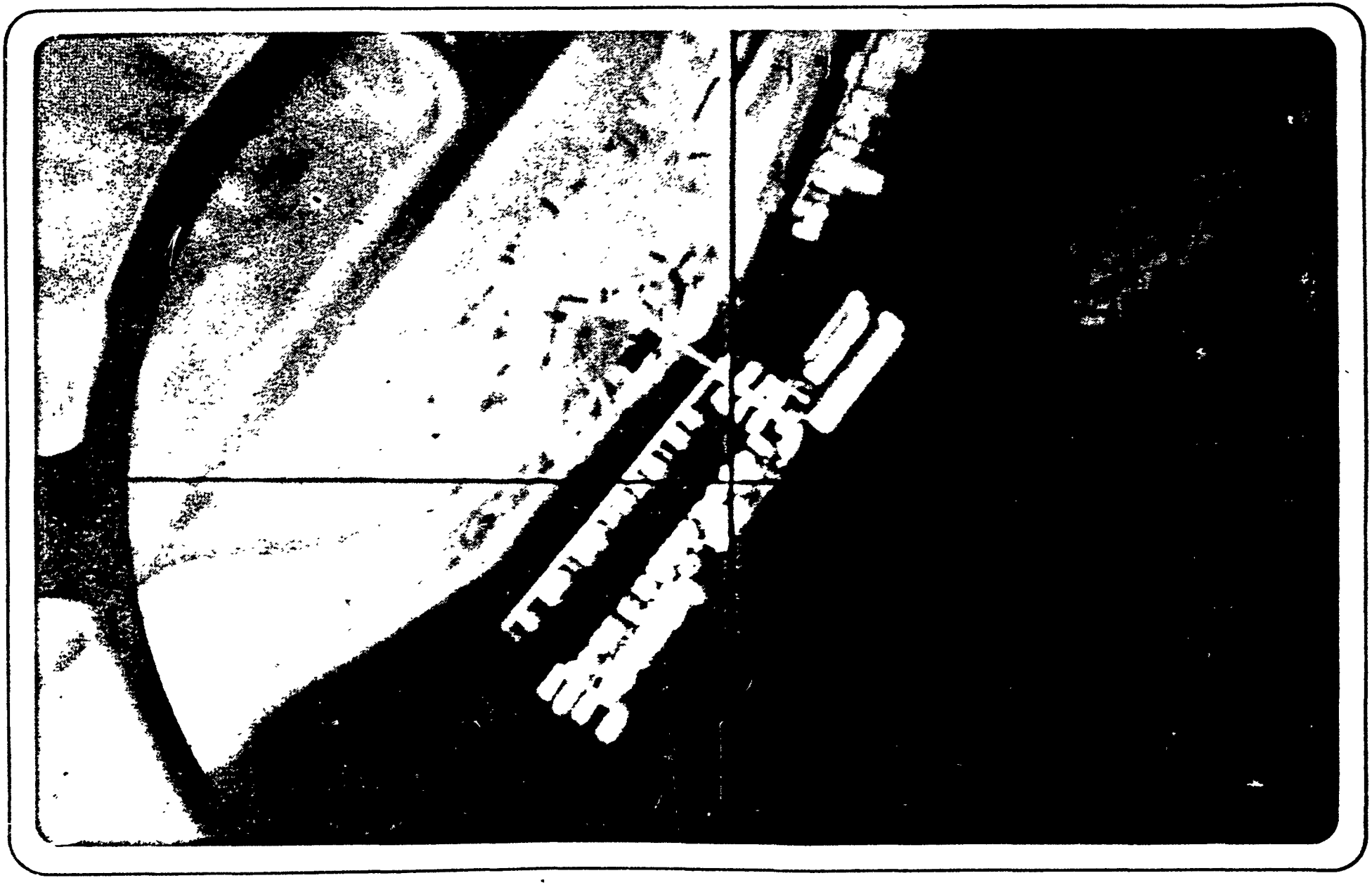
Photograph 2-10 Pool 16, RM 478.5 - 483, 11 August 79 9" x 9" Flight



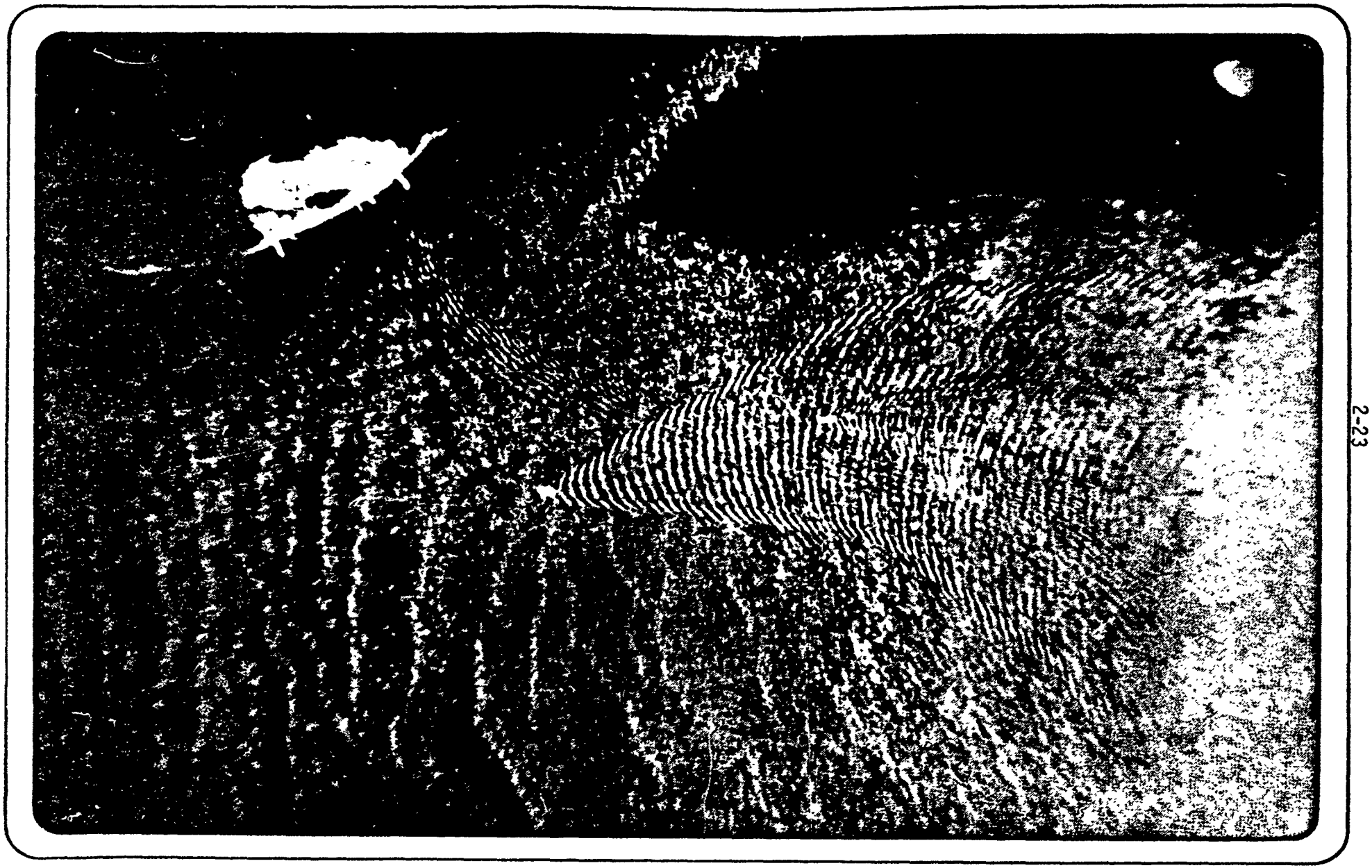
Photograph 2-11 Pool 16, RM 481.5 - 485.5, 11 August 79 9" x 9" Flight



Photograph 2-12 Barge-Tow Complex



Photograph 2-13 Deck-Hull Motorcraft in Marina Complex



Photograph 2-14 Open-Hull Motorcraft Underway with Beaching Site

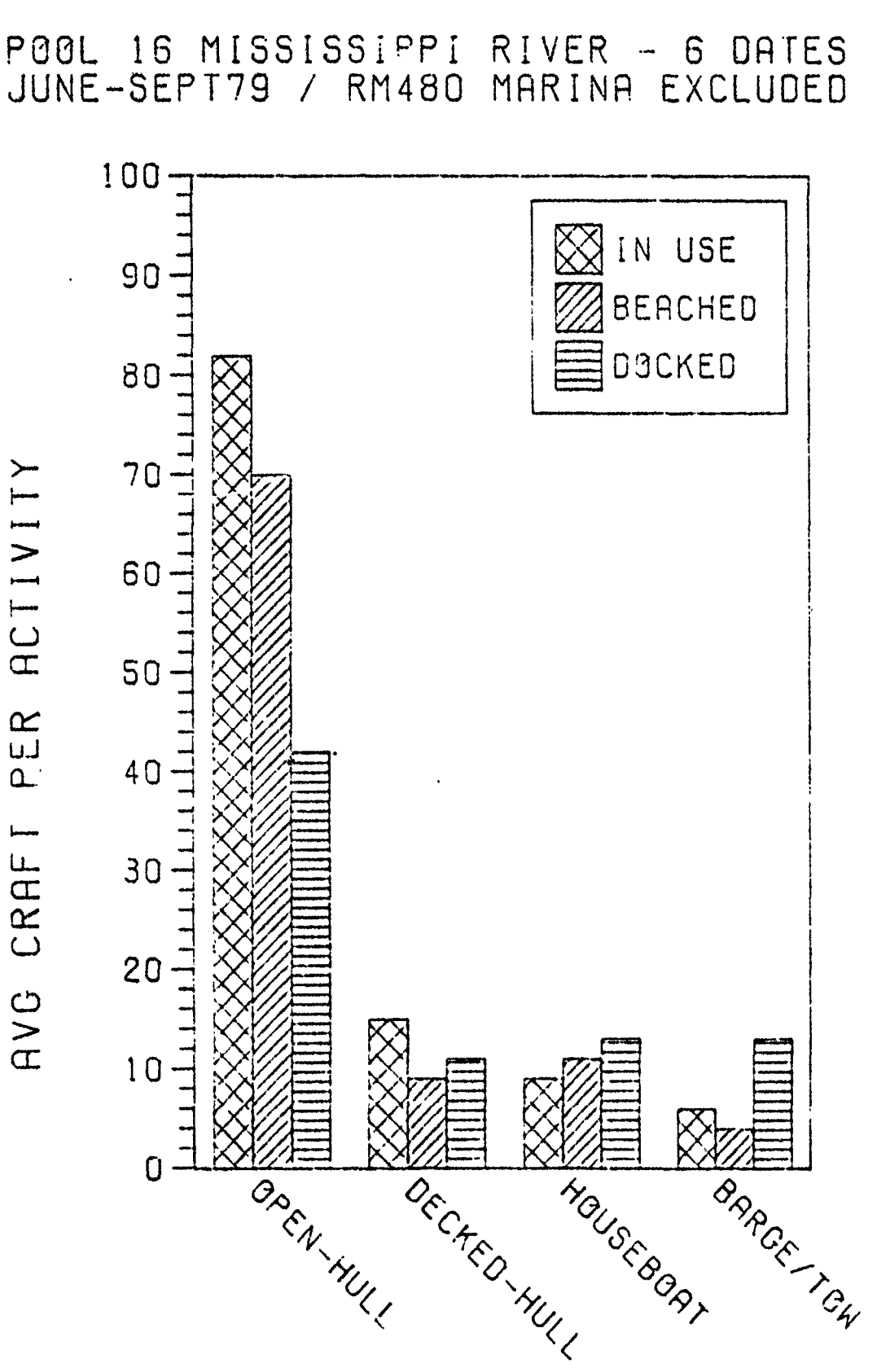


Figure 2-1 General Watercraft Activity Status

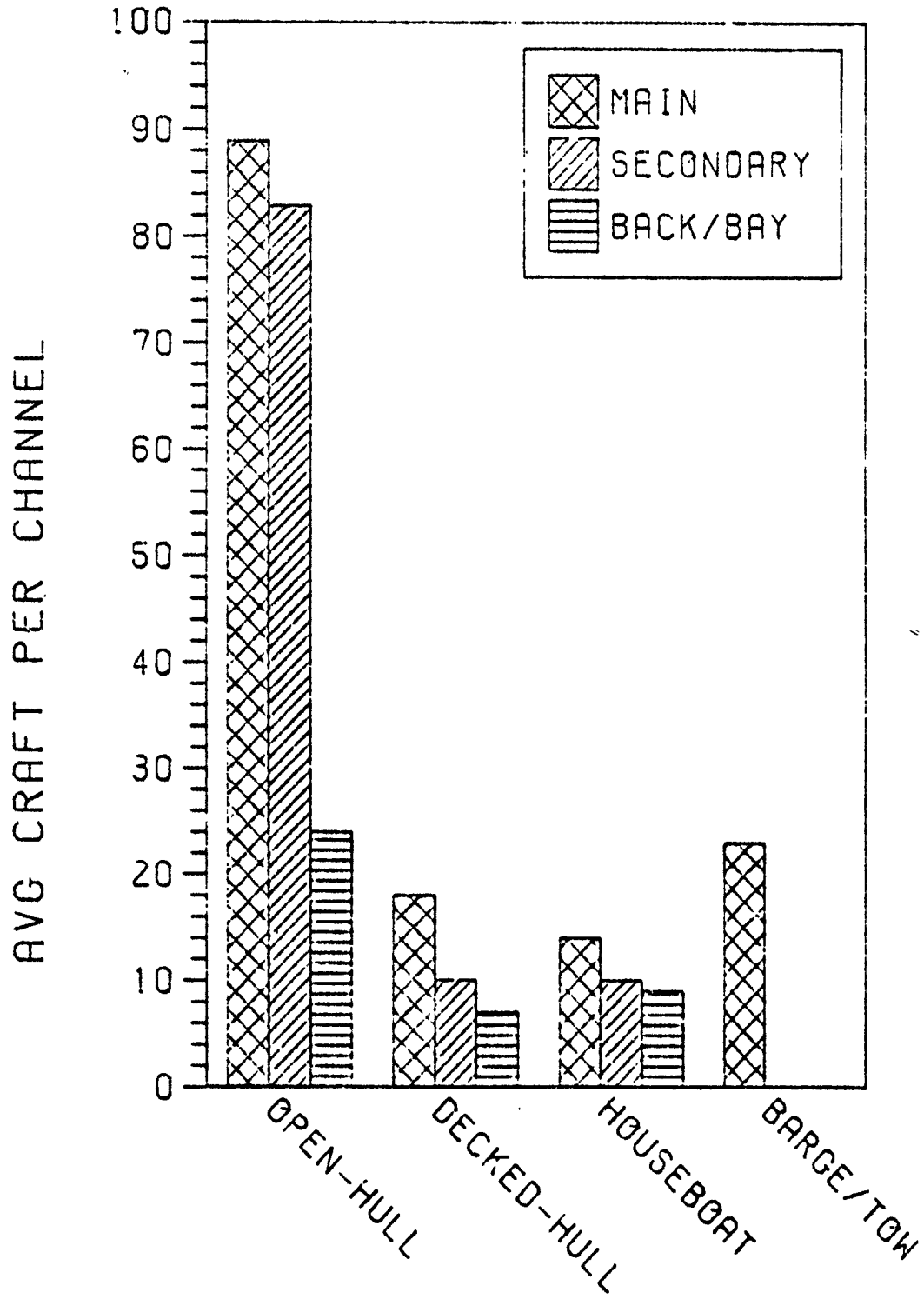


Figure 2-2 Watercraft Location by Channel

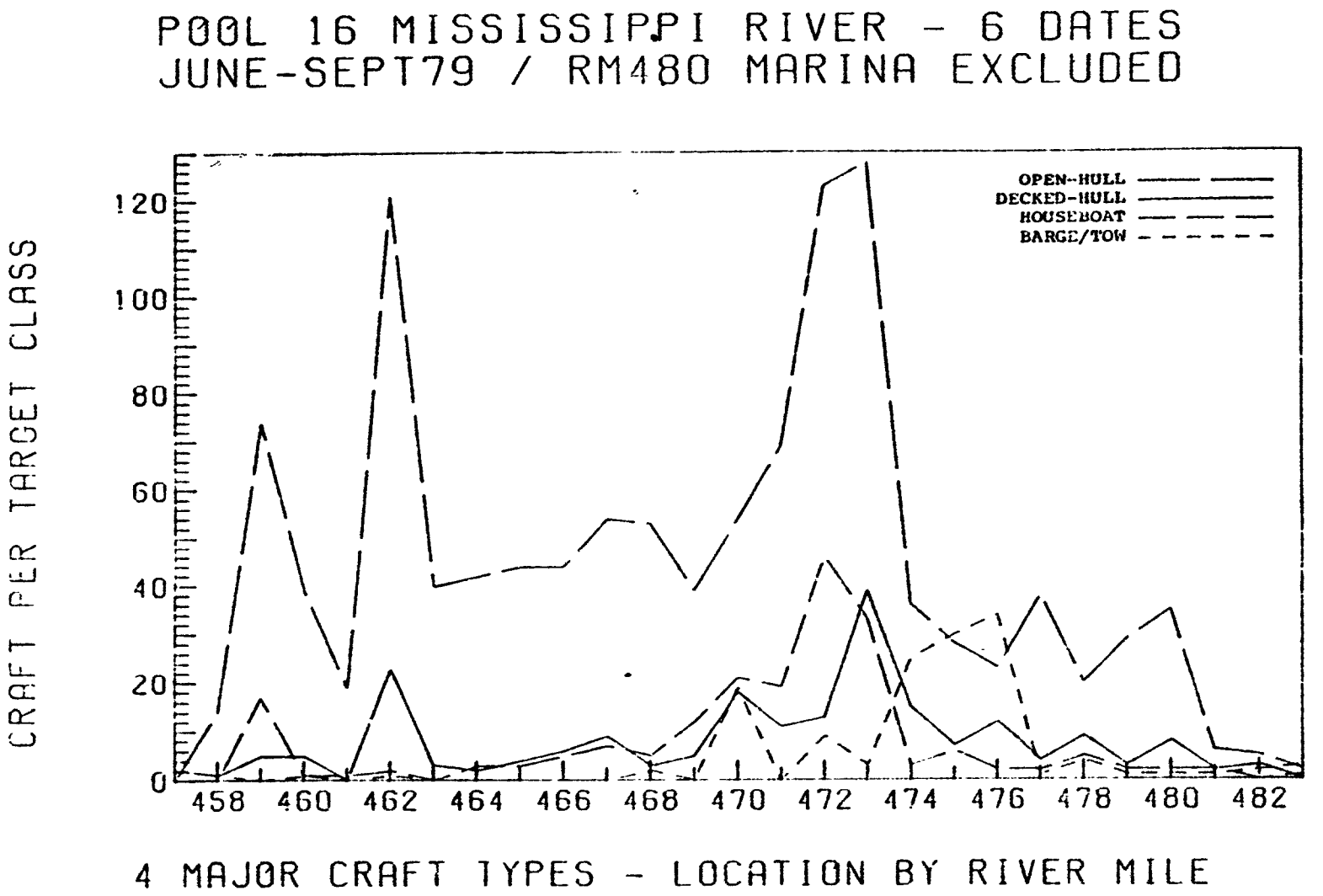


Figure 2-3 General Craft Distribution

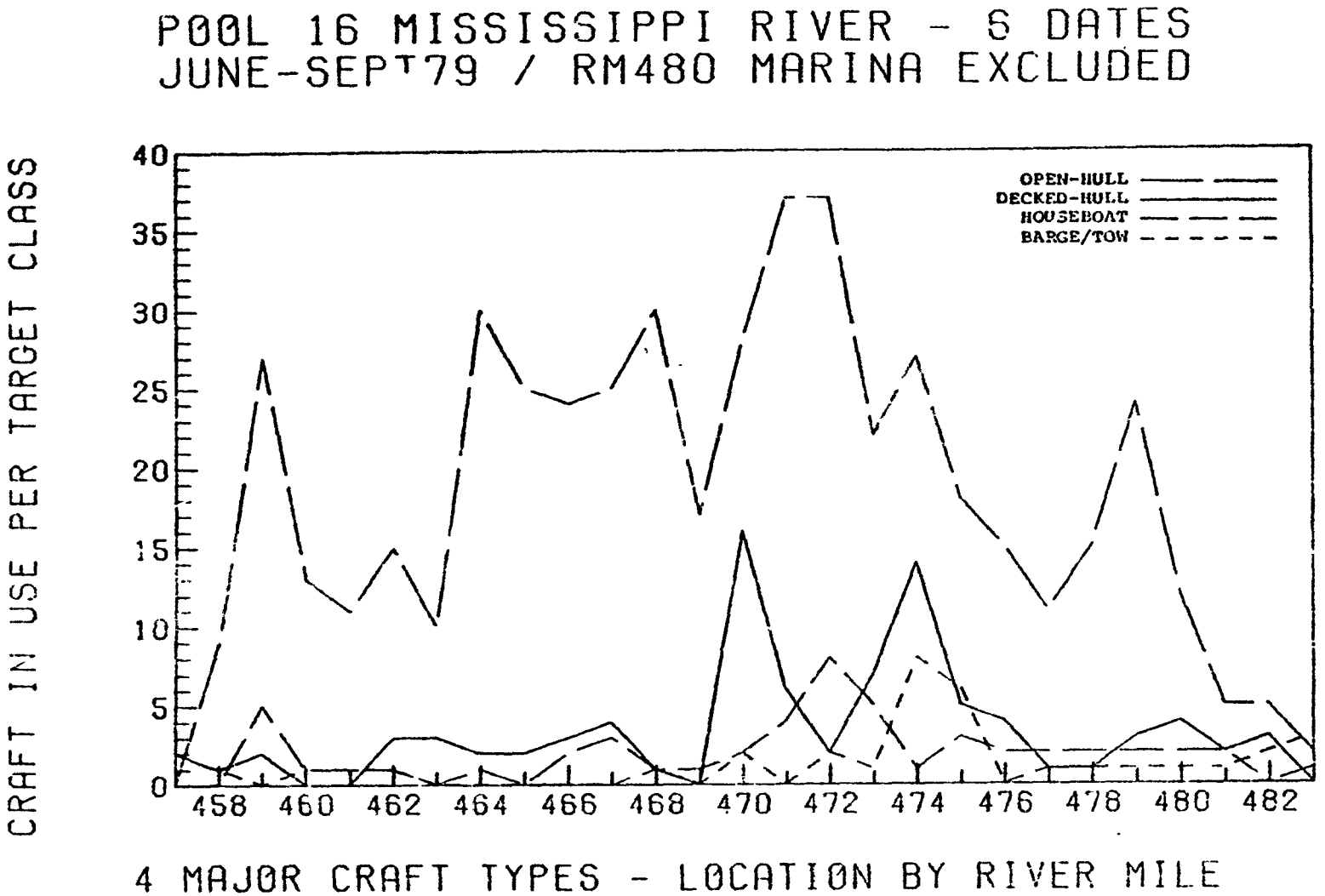


Figure 2-4 Distribution of Craft in Use

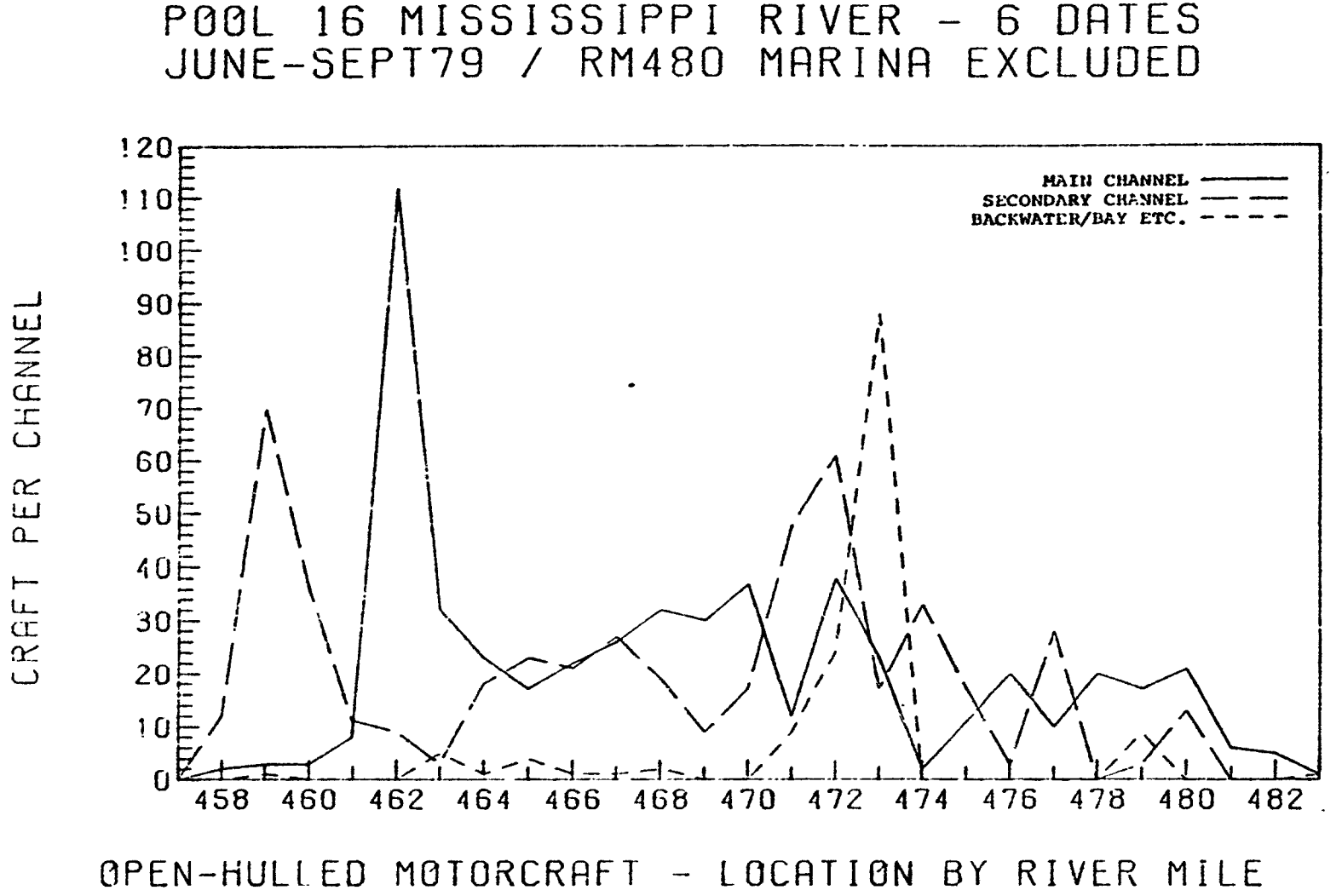


Figure 2-5 Open-Hulled Motorcraft Distribution

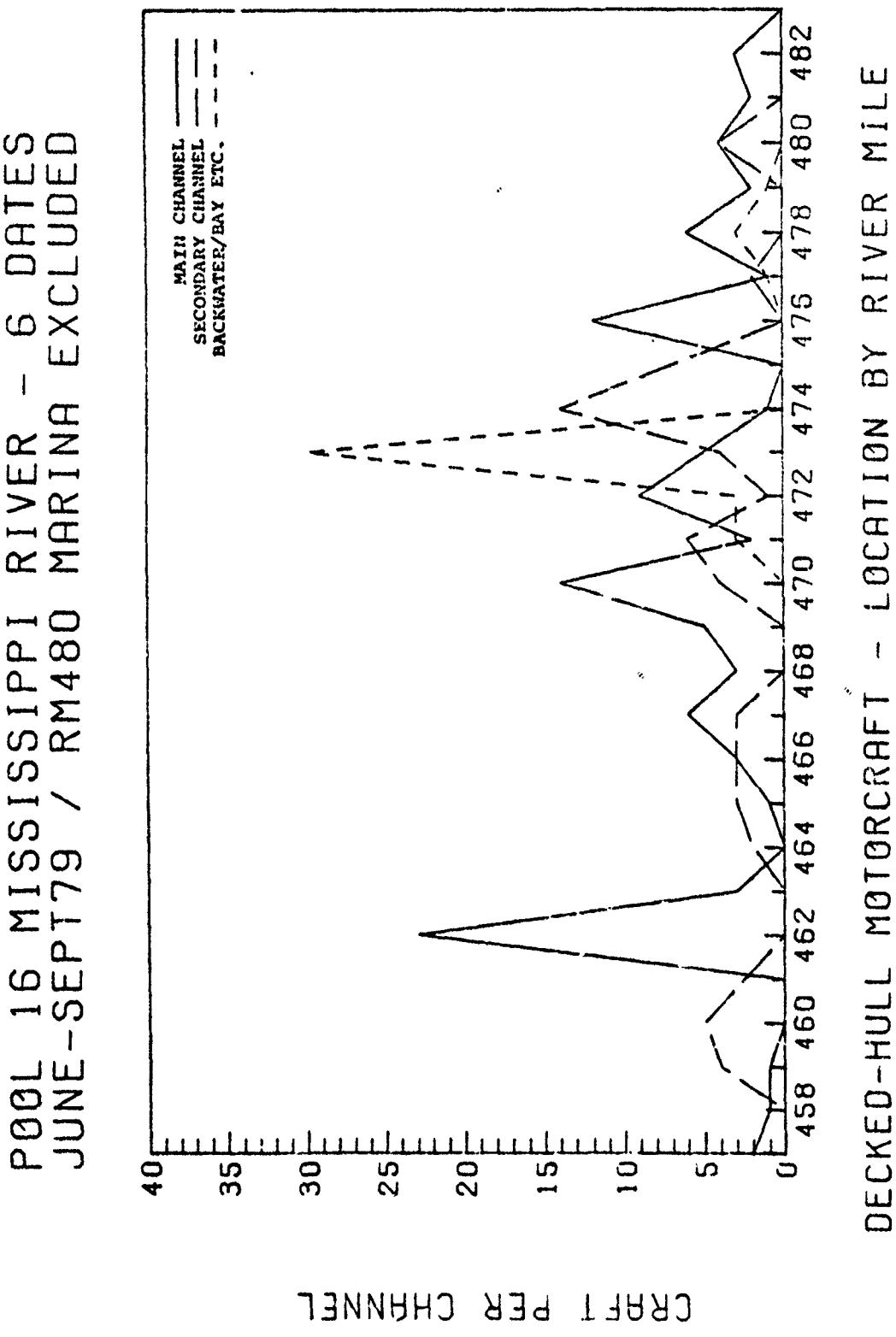


Figure 2-6 Decked-Hull Motorcraft Distribution

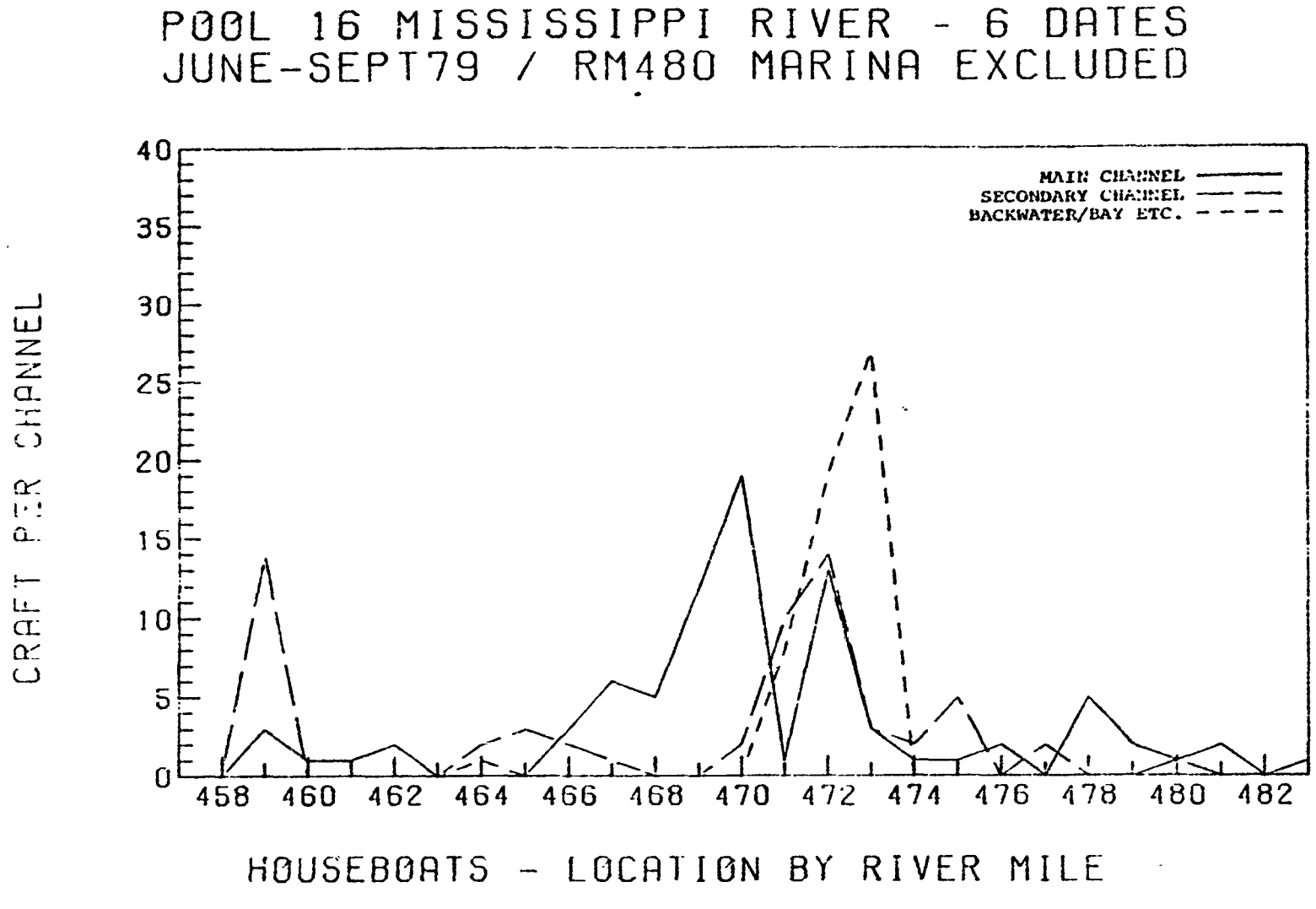


Figure 2-7 Houseboat Distribution

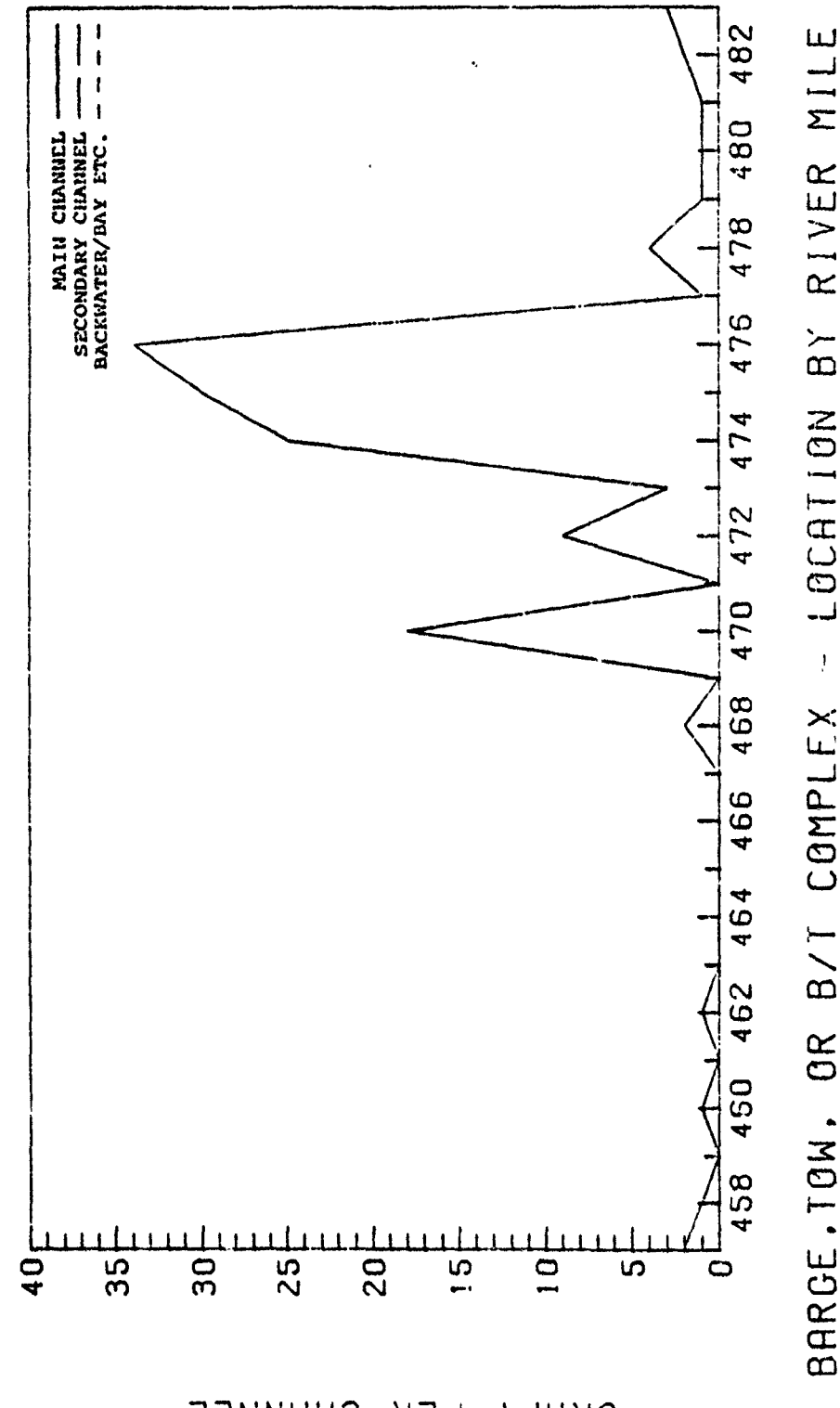


Figure 2-8 Barge and/or Tow Distribution

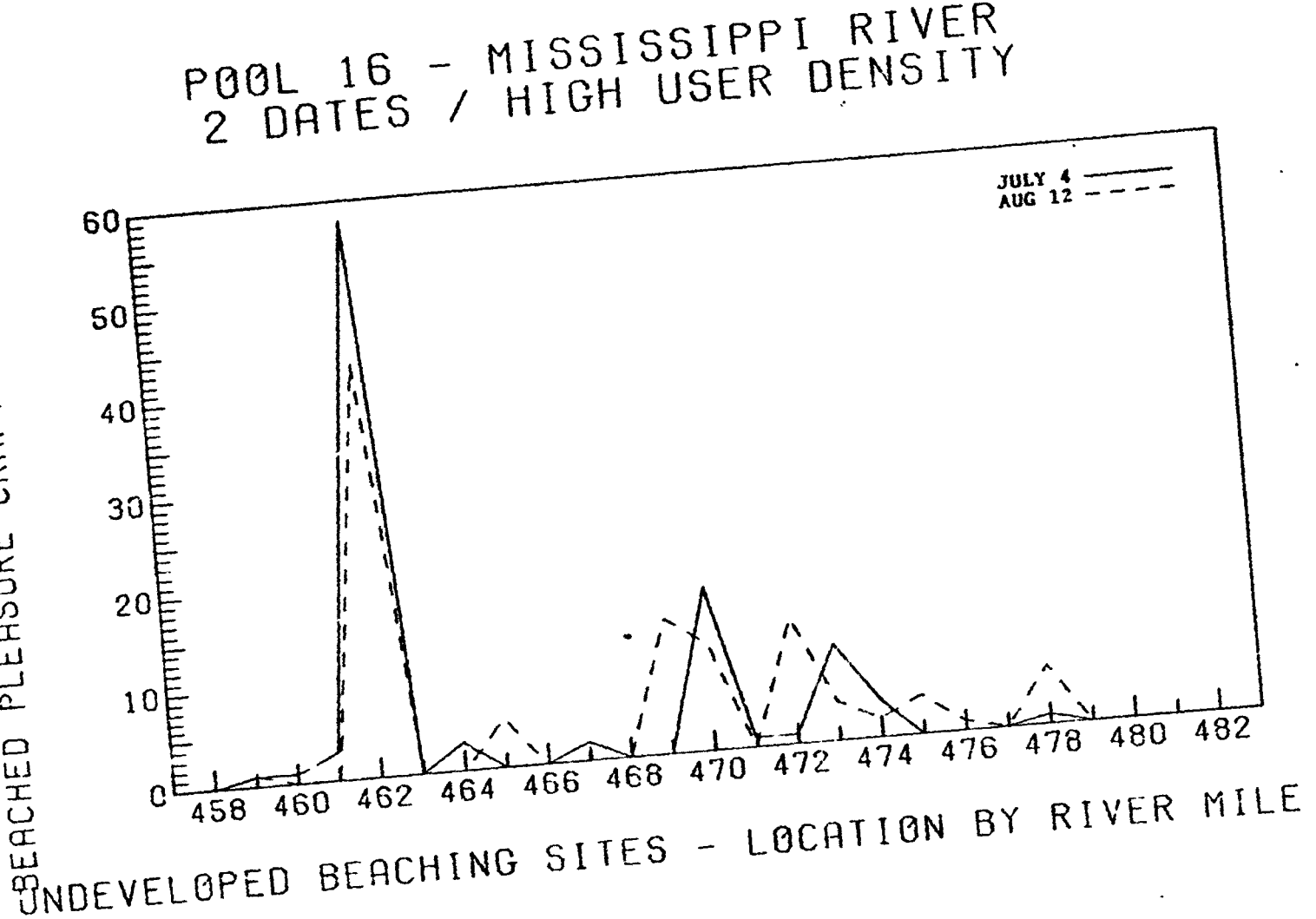


Figure 2-9 Undeveloped Beaching Sites - Dates of High User Density

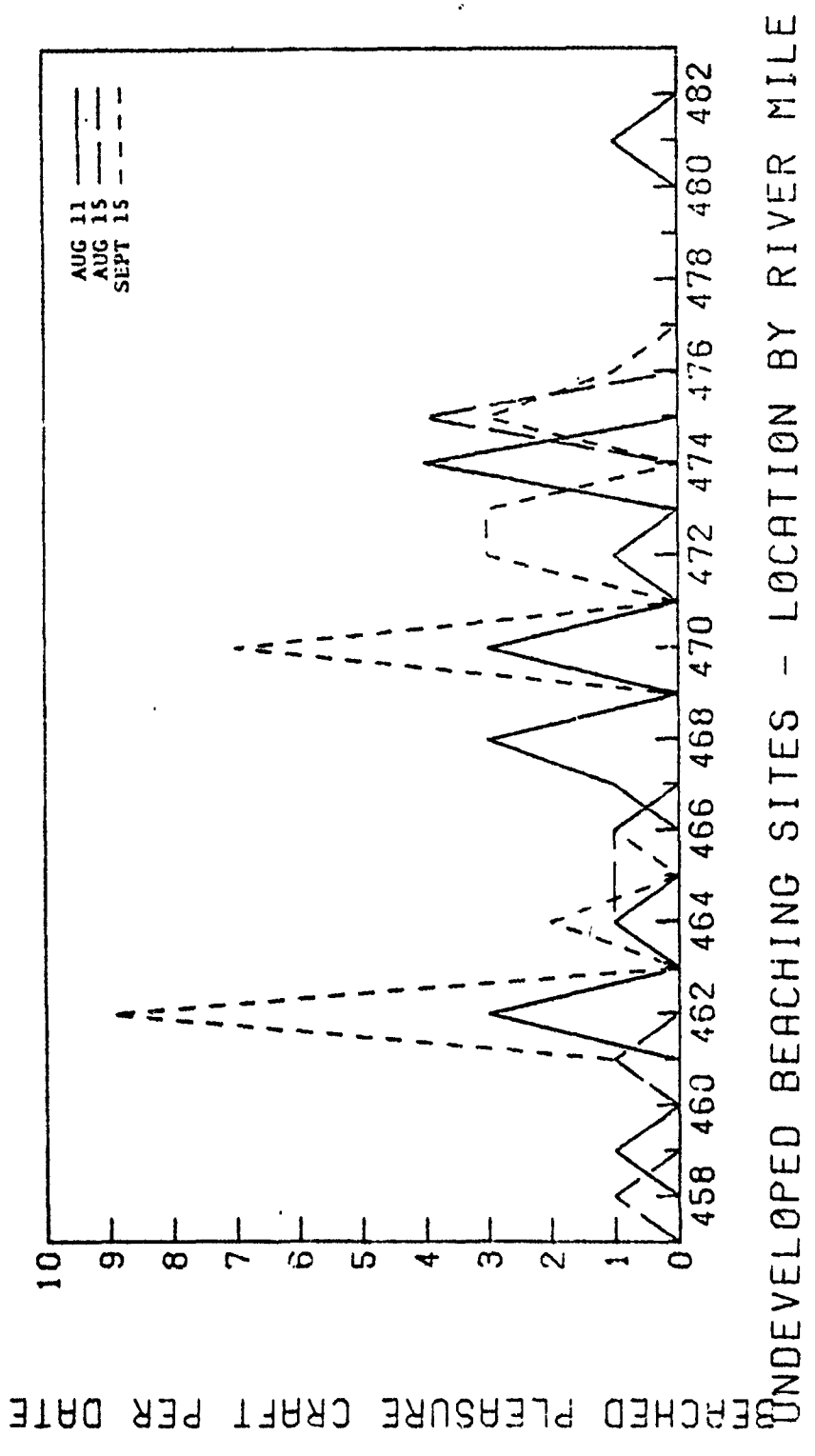


Figure 2-10 Undeveloped Beaching Sites - Dates of Low User Density

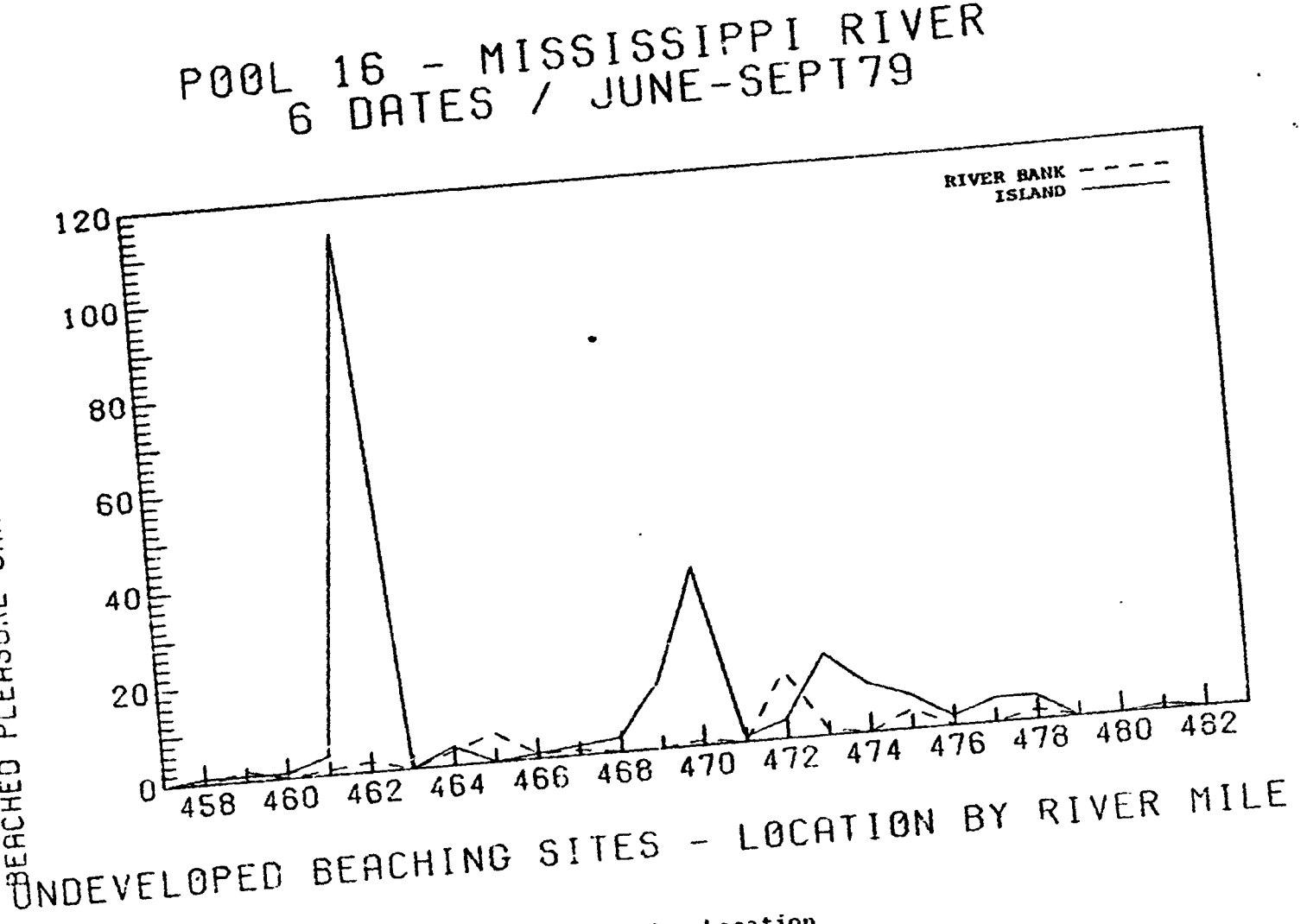


Figure 2-11 Undeveloped Beaching Sites - Shoreline Location

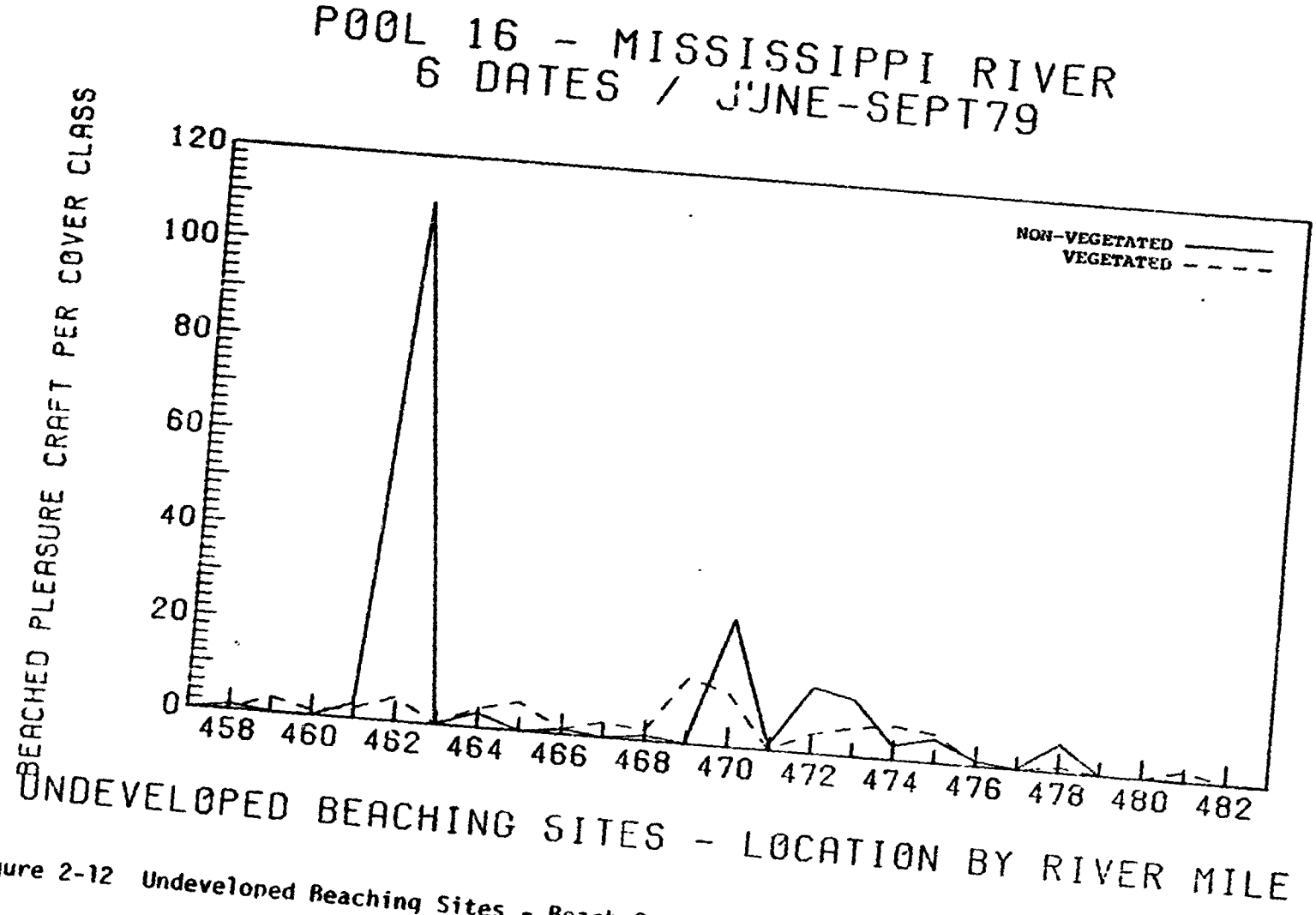


Figure 2-12 Undeveloped Beaching Sites - Beach Cover

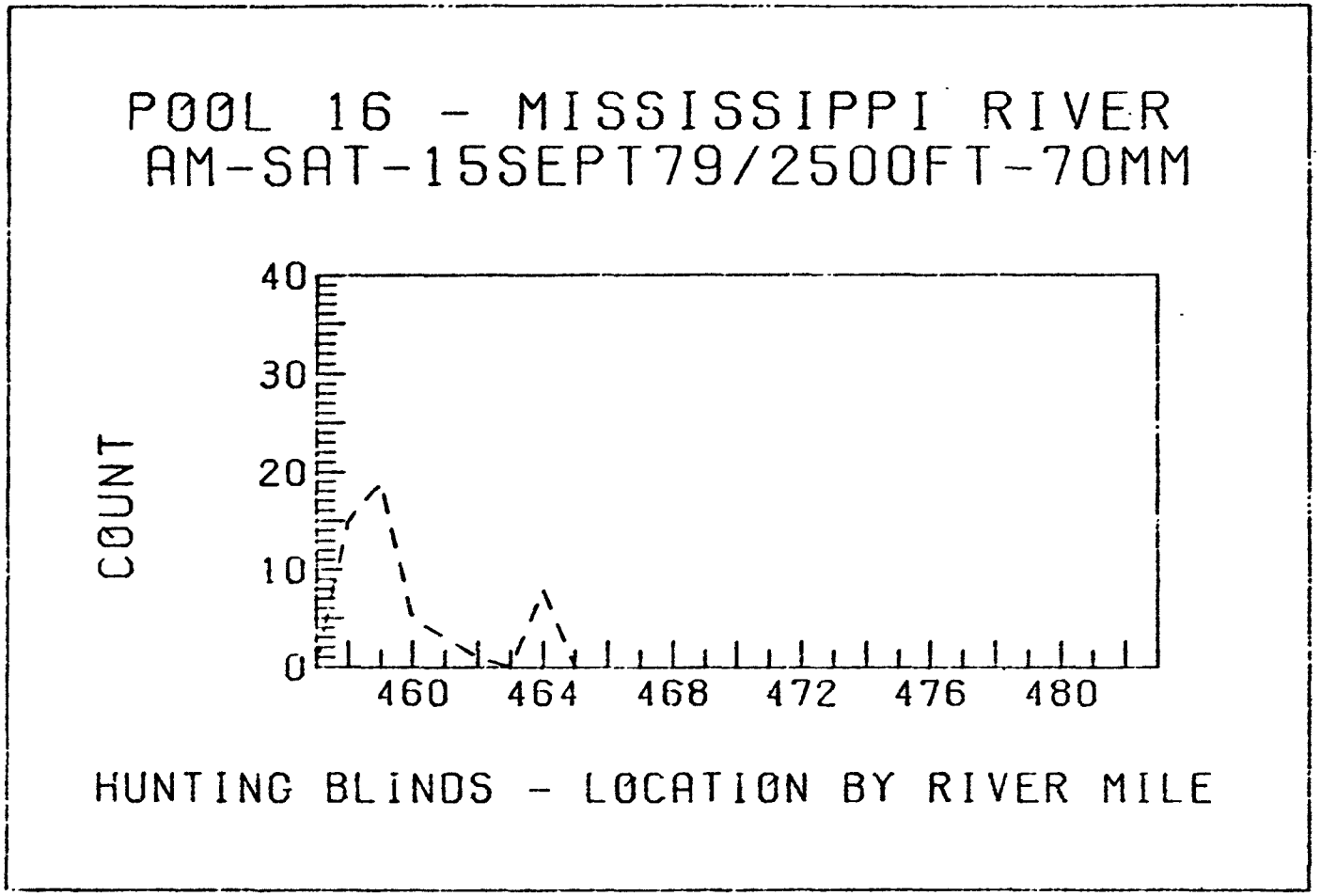


Figure 2-13 Hunting Blind Distribution

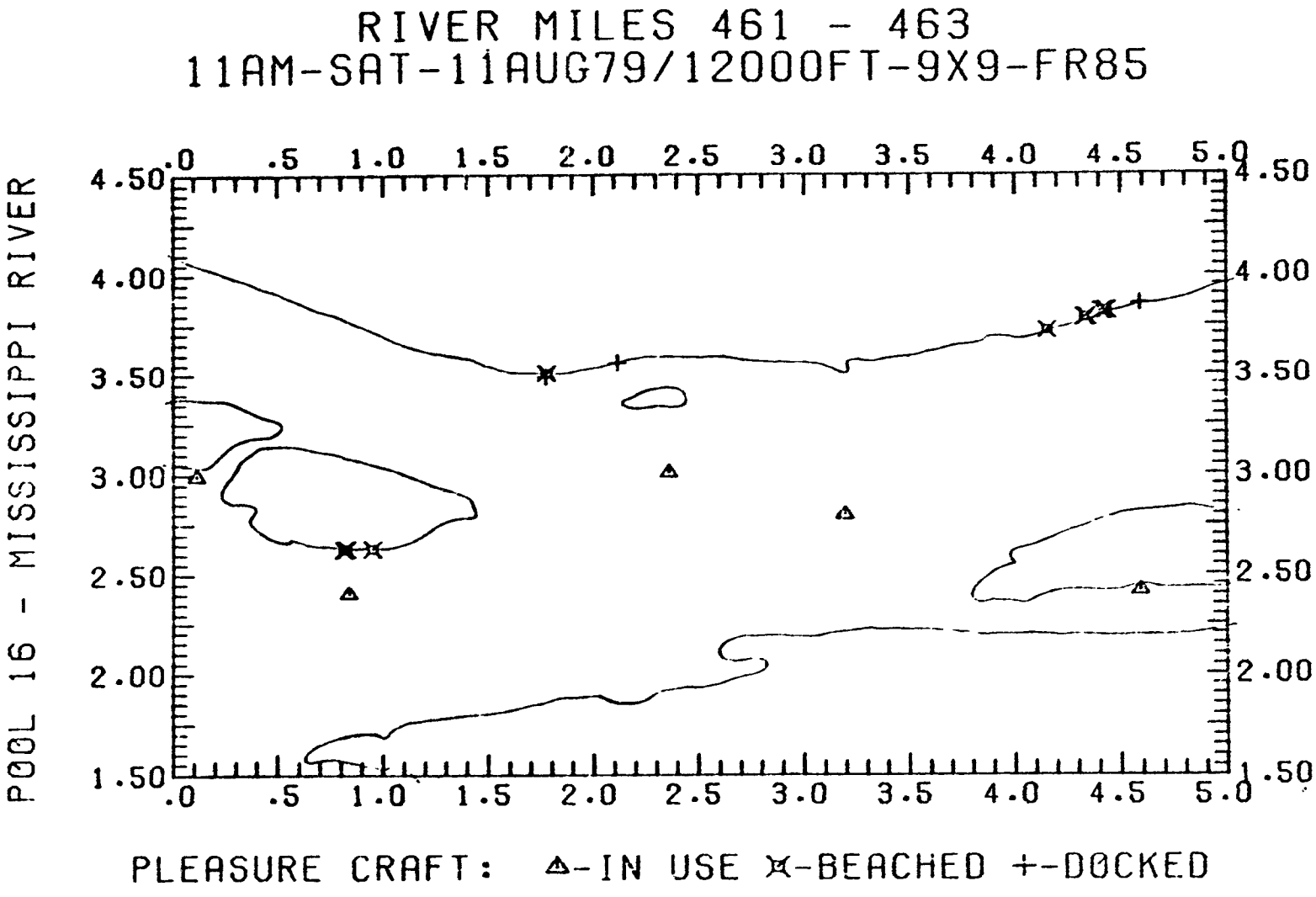


Figure 2-14 Craft Digitized from Section of Photograph 2-3. Shoreline Features Plotted Manually with Zoom Transfer Scope

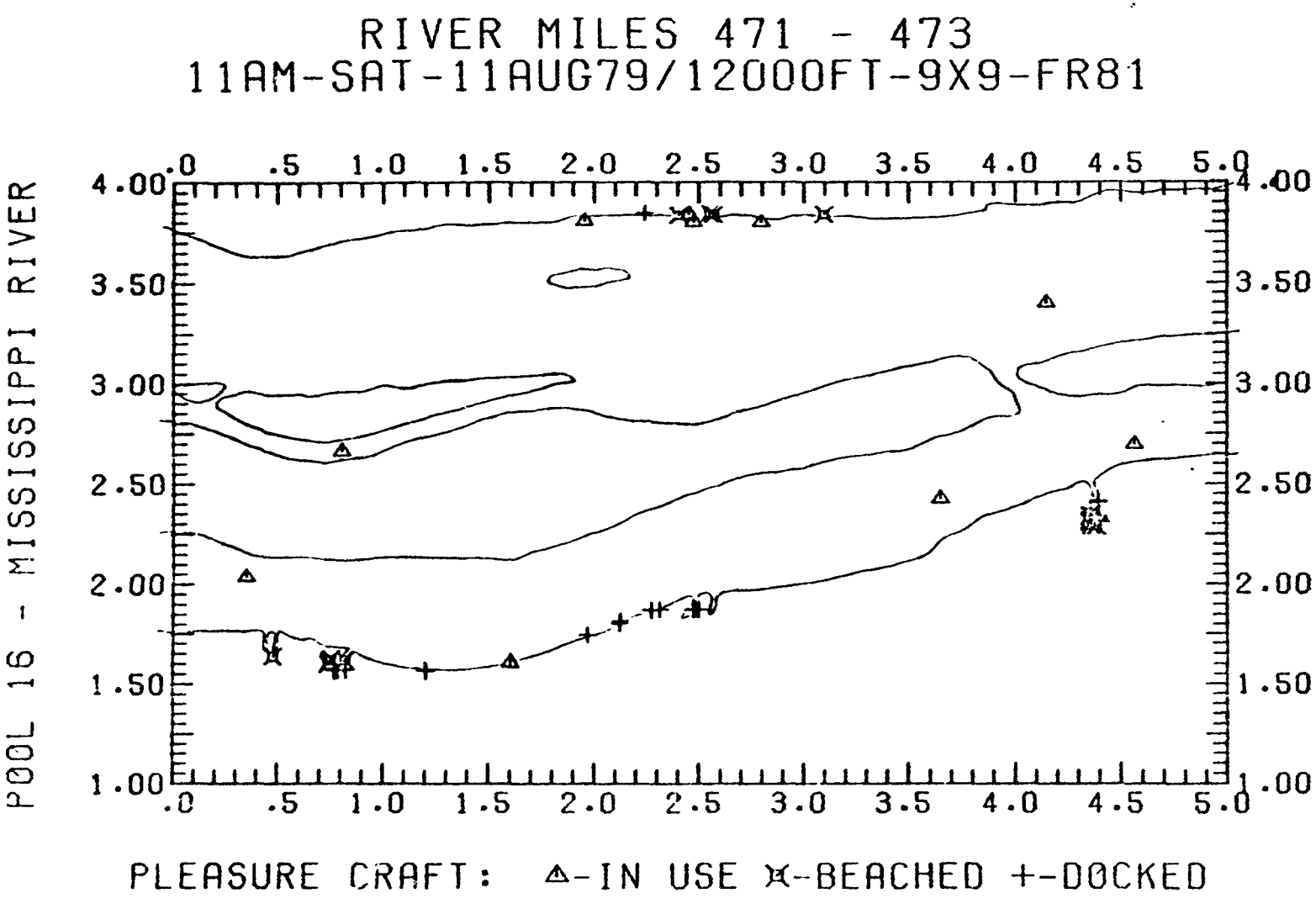


Figure 2-15 Craft Digitized from Section of Photograph 2-7. Shoreline Features Plotted Manually with Zoom Transfer Scope

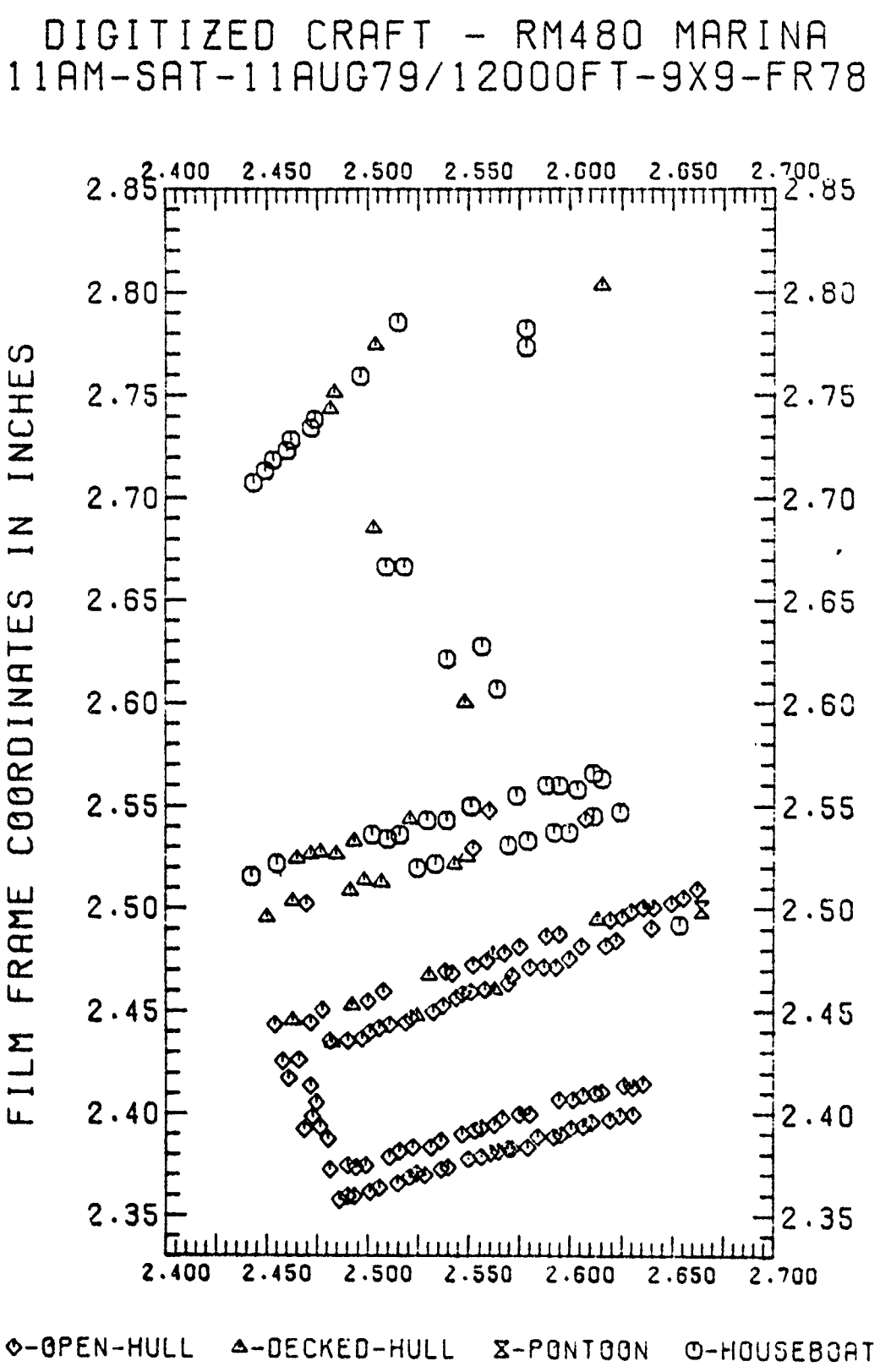


Figure 2-16 Craft Distribution - Rock Island Marina

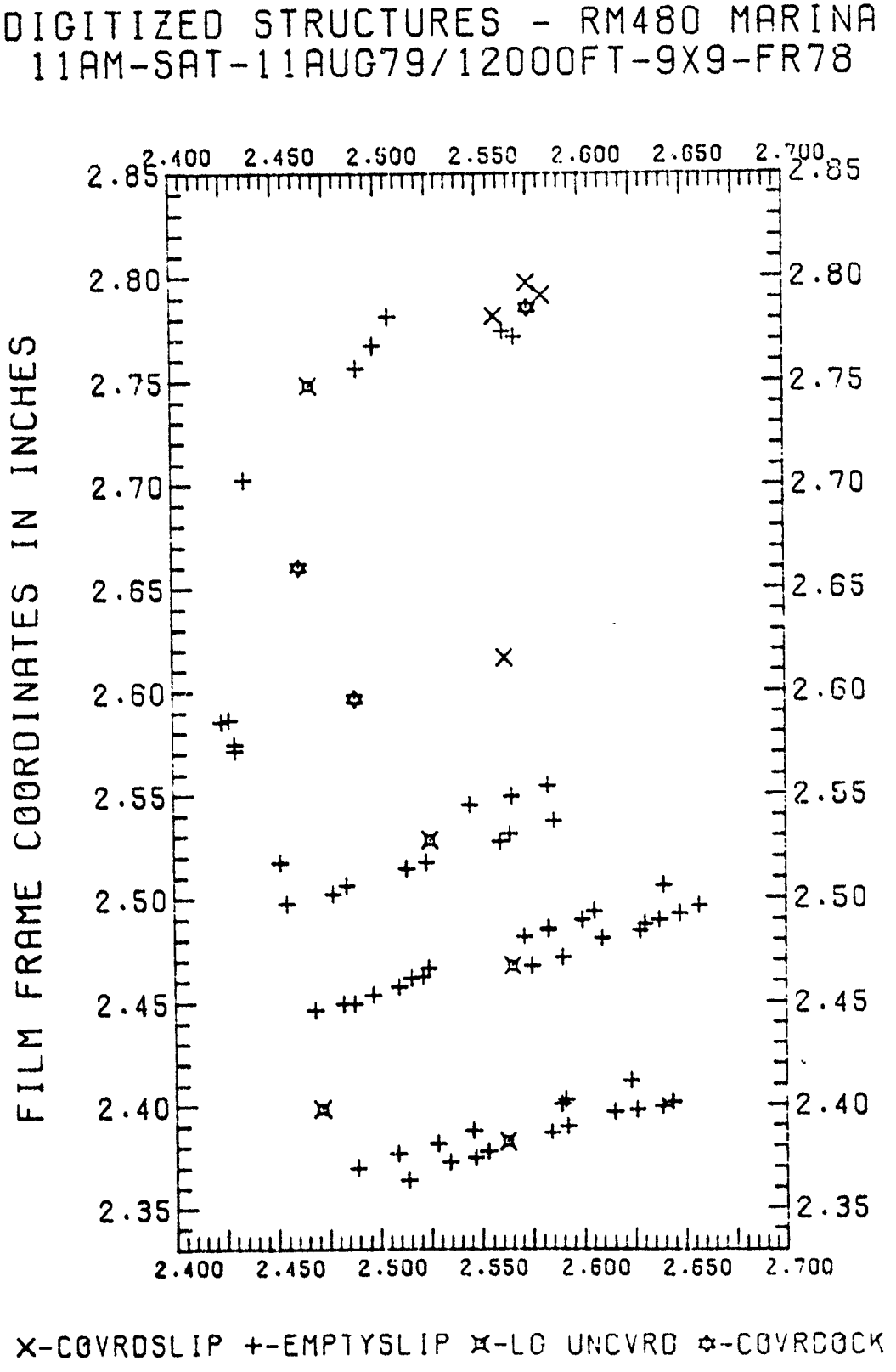


Figure 2-17 Structure Distribution - Rock Island Marina

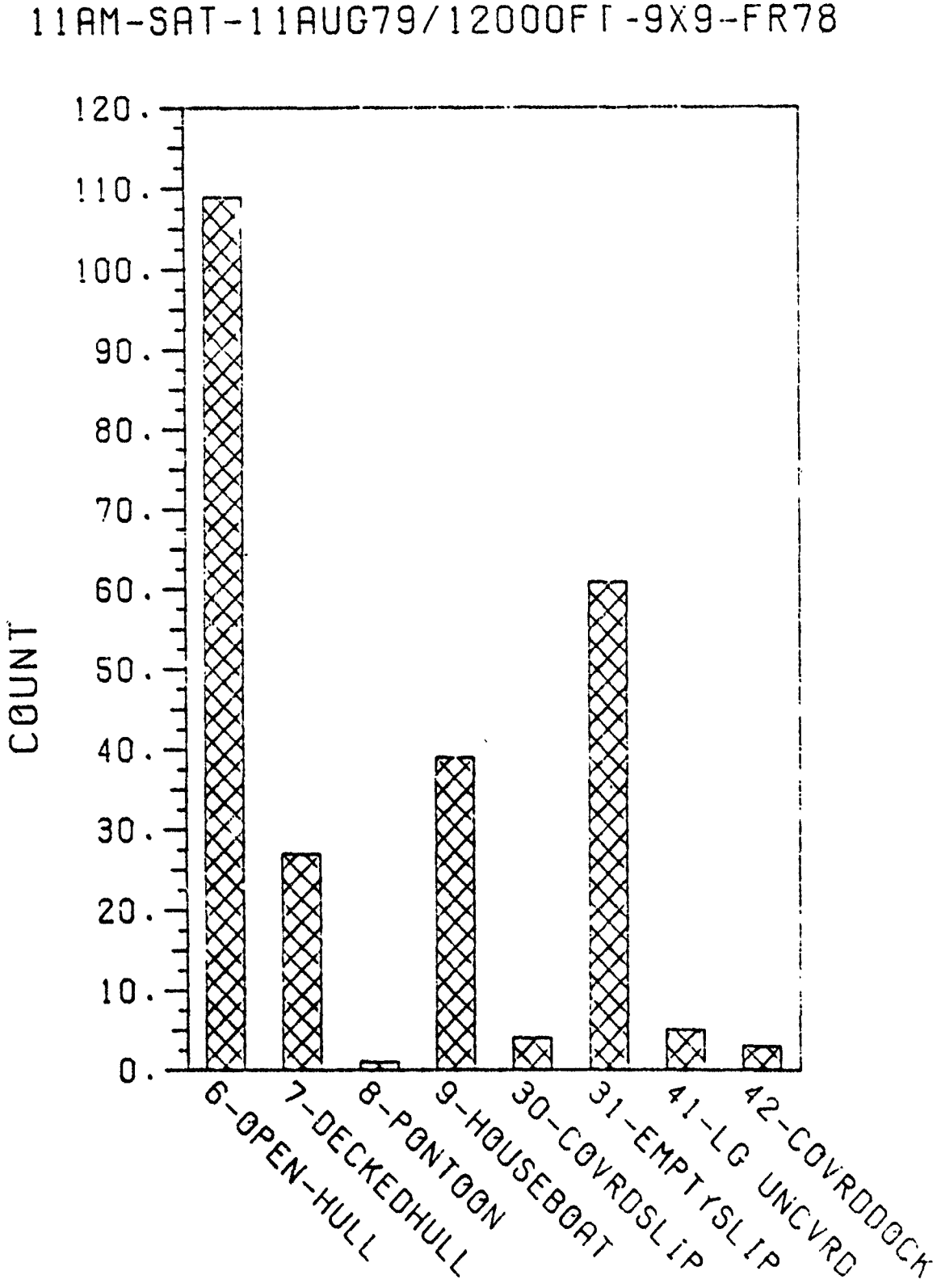


Figure 2-18 Target Classes Present - Rock Island Marina

TABLE 2-1 Target Frequencies for Pool 16
(River Mile 480 Marina Excluded)

Target (Type of Craft or Structure)	Handbook Code	Absolute Frequency	Approximate Percent
Canoe	1.	33	1.2
Rowboat	2.	4	.1
Inflatable	3.	2	.1
Sailboat under Sail	4.	24	.9
Sailboat not under Sail	5.	9	.3
Open-Hull Motorcraft	6.	1182	43.4
Deck-Hull Motorcraft	7.	213	7.8
Pontoon	8.	13	.5
Houseboat	9.	200	7.3
Barges - No Tow	10.	96	3.5
Barge-Tow Complex	11.	24	.9
Tow Only	12.	20	.7
Excursion Boat	13.	7	.3
Hunting Blind	20.	135	5.0
Covered Boat Slip	30.	208	7.6
Empty Boat Slip	31.	16	.6
Small Uncovered Dock	40.	468	17.2
Large Uncovered Dock	41.	28	1.0
Covered Dock	42.	4	.1
Industrial-Comm. Dock	44.	38	1.4
Total		2724	100.0

TABLE 2-2 Target Frequencies for Pool 16
(River Mile 480 Marina Excluded)

River Mile (RMILE)	Absolute Frequency	Approximate Percent
457	4	.1
458	65	2.4
459	204	7.5
460	78	2.9
461	25	.9
462	171	6.3
463	65	2.4
464	86	3.2
465	75	2.8
466	112	4.1
467	114	4.2
468	96	3.5
469	76	2.8
470	131	4.8
471	145	5.3
472	281	10.3
473	442	16.2
474	86	3.2
475	89	3.3
476	104	3.8
477	69	2.5
478	54	2.0
479	43	1.6
480	66	2.4
481	15	.6
482	16	.6
483	9	.3
Total	2724	100.0

TABLE 2-3 Target Frequencies for Pool 16 for Three Dates (River Mile 480 Marina Excluded)[1]

TARGET	CODE	June 21		July 4		Aug. 11	
		Frequency	Approximate Percent	Frequency	Approximate Percent	Frequency	Approximate Percent
Canoe	1.	1	.5	5	.8	15	4.2
Rowboat	2.	1	.3	0	0	0	0
Inflatable	3.	0	0	1	.2	0	0
Sailboat Under Sail	4.	3	1.4	17	2.8	0	0
Sailboat Not Under Sail	5.	1	.5	4	.7	0	0
Open-Hull Motorcraft	6.	84	39.4	318	53.3	125	34.7
Deck-Hull Motorcraft	7.	9	4.2	64	10.7	19	5.3
Pontoon	8.	0	0	3	.5	1	.3
Houseboat	9.	13	6.1	36	6.0	23	6.4
Barges - No Tow	10.	18	8.5	12	2.0	20	5.6
Barge-Tow Complex	11.	7	3.3	4	.7	3	.8
Tow Only	12.	1	.5	4	.7	3	.8
Hunting Blind	20.	2	.9	13	2.2	22	6.1
Covered Boat Slip	30.	34	16.	37	6.2	36	10.0
Empty Boat Slip	31.	1	.5	5	.8	2	.6
Small Uncovered Dock	40.	32	15.0	0	0	3	.8
Large Uncovered Dock	41.	5	2.3	0	0	3	.8

TARGET	CODE	June 21		July 4		Aug. 11	
		Frequency	Approximate Percent	Frequency	Approximate Percent	Frequency	Approximate Percent
Covered Dock	42.	2	.9	2	.3	0	0
Industrial Commercial Dock	44.	0	0	12	2.0	11	3.1
Totals		213	100.0	597	100.0	360	100.0

[1] See Book 1, Part 1 for additional frequencies

TABLE 2-4 Rock Island Marina Watercraft and Empty Slip Data (Exclusive of Covered Docks)

	June 21	July 4	Aug. 11	Sept. 15	Average
All Craft	149	122	180	172	215
Empty Slips	53	76	61	45	59
Total	202	198	241	217	

SECTION 3.
EVALUATION OF METHODOLOGY

TABLE OF CONTENTS - SECTION 3

	Page
EVALUATION OF METHODOLOGY	3-4
PERSONNEL AND EQUIPMENT REQUIREMENTS	3-4
TIME REQUIREMENTS	3-4
Time Requirements for All Pools	3-4
Time Requirements for Pool 16	3-5
Conclusions in Respect to Time	3-5
COSTS	3-6
Costs for Aerial Photography for All Pools	3-7
Cost for Data Entry and Analysis	3-7
Cost Per Target	3-7
Conclusions in Respect to Cost	3-7
RELIABILITY	3-8
Negative Factors Affecting Reliability and Acquisition of Aerial Photographic Acquisition	3-8
Camera System Failure	3-8
Flight Planning and Execution Failure	3-8
Negative Factors Affecting Reliability and Useability of Aerial Photographic Target Interpretation	3-8
Target Encoding Error	3-8
Mis-coding Values	3-9
Film Handling Errors	3-9
Positive Factors for Acquiring Aerial Photography (Recommendations)	3-9
Positive Factors in Improving Reliability and Useability of Aerial Photographic Target Interpretation	3-9
Handbook Development	3-9
ORION System and Software	3-10
Zoom Stereoscope/Talos Digitizer/ORION System	3-10
ERROR ESTIMATES	3-12
Error Examples	3-12
Target Confusion and Confidence Measures	3-13
Docks	3-14
June 21 Reliability Test	3-16

LIST OF TABLES

Tables		Page
3-1.	Personnel Requirements	3-17
3-2.	Equipment Requirements	3-18
3-3.	Time Requirements for All Pools in Hours	3-19
3-4.	Time Requirements for Aerial Initial Photography Interpretation Task for Pool 16 in Hours	3-21
3-5.	Flight Time Requirements for Pool 16 (not including contracted 9" x 9" photography)	3-22
3-6.	Time Required to Interpret Aerial Photography for Pool 16 in Minutes	3-23
3-7.	Average Time per Target for Pool 16 in Minutes	3-24
3-8.	Costs for Aerial Photography Planning for All Pools (in 1979 dollars)	3-25
3-9.	Cost for Aerial Photography Acquisition for all Pools	3-26
3-10.	Costs and Characteristics of the Target Data Collection and Interpretation System (in 1979 dollars)	3-27
3-11.	Costs for Data Entry and Analysis for Pool 16	3-28
3-12.	Per Target Costs for Pool 16	3-29
3-13.	Air Photo Errors vs. Flight Date (errors typical of those affecting interpretability)	3-30
3-14.	Acquisition/Interpretation Suitability Matrix for Formal System vs. Operational Factors	3-31
3-15.	Classification Reliability Matrix for Format/Photo Scale vs. Boat Type	3-33
3-16.	Target Confusion Matrix	3-34
3-17.	River Mile by Flight Date Crosstab Excluding 480 Marina for Small Uncovered Docks (Target Code 40)	3-36
3-18.	Re-examined Small Uncovered Dock Counts	3-37
3-19.	Interpretation Reliability: 21 June Flight	3-38

EVALUATION OF METHODOLOGY

This section includes discussion concerning the equipment and personnel, time, and cost requirements to develop, test, and operationalize this methodology. It also includes our evaluation of the method in respect to factors which affect reliability, confidence, and watercraft interpretation, and includes error estimates.

PERSONNEL AND EQUIPMENT REQUIREMENTS

The methods utilized require the use of somewhat soohisticated equipment thereby requiring certain personnel abilities (see Table 3.1). As noted, this includes individuals with computer programming experience or education, and airphoto interpretation experience. The methodology, if utilized in its present configuration, would not require the level of stated skill levels, Airphoto training could be accomplished without intensive formal education. Except for the pilot and some aspects of the statistical analysis, various types of personnel could be trained to operate the methodology.

In respect to equipment, there are some essential items (see Table 3.2). Acquiring of 70mm film requires access to various items including an airplane camera, etc. Interpretation of the aerial photography requires access to a small mini-computer such as the Orion, a back lighted digitizer, plus a zoom stereoscope. There are potential variations within each of the equipment items but differences would cause software alterations and adaptations. Main frame computing access is necessary for analysis and graphic displays. The equipment requirements consist of "off the shelf" technology. The personnel needs will possibly require some training of existing individuals or the hiring of university graduates with remote sensing, resource analysis, or planning backgrounds.

TIME REQUIREMENTS

Time requirements are reported in various forms. Estimates are provided which reflect the time to develop and operationalize the methodology (initial time) and to conduct and apply the methodology (recurring time) again without major modifications. Time utilized to obtain and coordinate photography for all pools is separated from the analysis of Pool 16.

Time Requirements for All Pools

To develop and operationalize the methodology for all pools required approximately 1660 hours (see Table 3.3). These estimates are based upon keeping general records of time spent conducting various tasks. The various tasks include such things as planning for the aerial photography, acquiring the photography, development of the handbook/codebook, training and software development. We estimate to obtain the same amount of aerial

photography for all pools would require approximately 625 hours of personnel time, assuming the use of the same equipment, the same personnel, the same procedures, the same software, etc.

Time Requirements for Pool 16

To interpret, transfer, and analyze six flights of aerial photography for pool 16 initially required approximately 315 hours (see Table 3.4). This does not include acquisition of aerial photography (see Table 3.5). We estimate to interpret, transfer and analyze an additional six flights would require approximately 255 hours.

In respect to the interpretation of the photography itself, six flights required approximately 11 hours for equipment set up, 134 hours for target interpretation, 20 hours for target maintenance, and 13 hours for equipment tear-down (see Table 3.6). Because the equipment was not located in a secure space, we had to set up and tear down equipment each time a roll of aerial photography was interpreted. This time could be reduced or eliminated depending upon the secureness of the space. The time estimates for each task are based upon a time log kept during the interpretation phase.

To obtain an average per target time estimate, the target interpretation time was divided by the number of targets interpreted per flight (see Table 3.6). This was accomplished for six flights on pool 16. The overall average time per target was 2.23 minutes or approximately 134 hours for the interpretation of 3673 targets. The lowest average per target interpretation time was .94 minutes on September 15 and the highest was 3.33 minutes on August 12 (see Table 3.7).

Conclusions in Respect to Time

This variance in time required deserves discussion. Targets included a variety of pool features including boats, docks, duck blinds, etc. A target such as a boat can be targeted in a marina, adjacent to a beach, underway, etc. The most efficient but tedious type of targets are located at large marinas such as the one in Pool 16 at river mile 480. In general the efficiency is due to reduced frame control set-up time, reduced necessity to scan the film for targets, and the repitition of similar targets. The least efficient targets are those which are scattered within the pool such as boats underway, beached at sand bars, fishing in backwaters, etc. To target watercraft of this type requires setting up each frame's control points, scanning the entire frame, and determining the type of target from a diverse set of potential target types.

Some additional discussion follows for each flight. The June 21 flight required 3.15 minutes per target. This relatively high target time is due to interpreter training and learning. This

was the first flight to be interpreted. This flight is useful because it probably represents the time required to be alloted for new unexperienced interpreters.

The July 4 flight is an excellent example because it includes the large marina at river mile 480 and a diverse set of targets distributed in a variety of locations in the pool.

The August 11 average per target time of 1.57 minutes was quite good. The primary reason for the good per target time is due to the large 9" x 9" film format. It requires considerably less per frame control point set-up time than the 70mm film format.

The August 12 per target time was 3.33 minutes. This was a very active use day on pool 16 with many targets spread over the pool. If the marina at river mile 480 had been fully imaged, the per target time would have probably been similar to the 2.78 per target time of July 4.

The August 15 weekday flight per target time as 1.63 minutes even though the marina at river mile 480 was only partially imaged. June 21 was also a weekday and low use day, but as stated earlier was the first flight to be interpreted. The 1.63 per target time in contrast to the August 12, 3.33 per target time is due to the elimination of frames because of the absence of watercraft in the pool. For example, on August 12, 446 watercraft were targeted of which 216 were in use (underway or idle). This means that about half of the watercraft (48%) were dispersed. On August 15, 215 watercraft were targeted of which 59 were in use (underway or idle). In contrast to August 12, only 22% of the watercraft were dispersed in the pool.

The September 15 flight per target time was .94 minutes. This time is a reflection of being the last flight interpreted, includes the large marina at river mile 480 and a concentration of new duck blinds in one portion of pool 16. This resulted in a very efficient time per target average.

In summary, the best approximation of per target time for new interpreters is June 21. For a busy summer weekend/holiday, July 4; for a large film format, August 11; and for a weekday, August 15.

COSTS

Cost estimates are presented in various forms. Costs are provided which reflect the costs to acquire the aerial photography, the cost to acquire essential aspects of the methodology such as the Orion computing system, estimated costs per target for six flights on pool 16, and estimated costs for data analysis and graphic display. The estimates do not include such considerations

as overhead, inflation, etc., and must be considered in respect to the unique considerations of pool 16 such as target density.

Costs for Aerial Photography for All Pools

The cost estimates for aerial photography include the planning aspects (see Table 3.8), 70mm film and processing costs, aircraft rental and the commercial contract for acquisition of the 9" x 9" infrared photography (see Table 3.9). The 70mm photography includes coverage of 51 pools or a per pool cost of approximately $200. The 9" x 9" contract photography includes all 12 pools for August 11. The per pool cost is approximately $400 per pool. This $400 represents the low bid price in which some bids were over twice the low bid.

Cost for Data Entry and Analysis

The methodology utilized to interpret, transfer and analyze the photography consists of various types of equipment, as described briefly before. The costs to purchase such a system are reflected in Table 3.10. The costs to utilize this equipment are reflected in Table 3.11.

Cost Per Target

To provide a comparison between various film formats and altitudes, Table 3.12 was developed. This table indicates that there is variance between the cost per target of 10¢ on July 4 and the cost per target of August 11 of 53¢. The difference between cost per target in this example is primarily related to the difference in film format costs. Differences in other per target costs are primarily related to the number of targets. The more targets, the lower the cost per target. This issue of target efficiency was discussed in the Time portion of this section.

Conclusions in Respect to Cost

In respect to the contract photography, it is most efficient when the target use is at its peak. If it would have been utilized on July 4 the per-target cost would have been 40¢ due to an additional 190 (799-609) targets present. Obviously, this holds for other photography but the reduction in set-up time is much faster.

In respect to using infrared film, it remains necessary at high altitudes for base control (i.e., 12,000 feet). At low altitudes such as 3500' and 2500', the additional cost is not warranted, particularly since it is more difficult to interpret watercraft (see discussion in this section on interpreter confidence).

From a cost consideration, there is also little to be gained by flying at the lower altitude of 2500 feet. This altitude requires approximately two times the amount of film which doubles the film and processing cost. In summary the most cost effective film is color (2448) and the most cost effective altitude is 3500'.

RELIABILITY

Negative Factors Affecting Reliability and Useability of Aerial Photography Acquisition

The acquisition of aerial photography requires careful preparation for and execution of each mission. The following discussion describes problems that may arise. The methodology section gives details concerning the planning and execution of missions. Table 3-13 summarizes problems actually encountered and Table 3-14 serves as an acquisition guide.

Camera System Failure

Some part of the mission or all will have no coverage. It is unlikely that such a failure would go undetected for very long during a mission. Acquisition of a backup camera and careful pre-flight checkout of other operating equipment can mitigate this problem. Problems can arise from battery supply, intervalometer or non-synchronous exposure.

Flight Planning and Execution Failure

Failures associated with flight planning and execution result in partial imaging, gaps in image end-lap, and exposure setting. The two former problems result in portions of the study area being missed entirely. The exposure setting (under or over) makes target interpretation more difficult.

Partial imaging results from flight planning error, pilot navigation error or weather conditions. It may also result from improper camera set-up. These problems are compounded by lower altitude missions. Gaps in end lap means intermittent portions of the study area are not imaged. They result from engine speed, weather, or exposure setting. Over or under exposure may be due to weather variability, mis-calculation or incorrect camera set-up.

Negative Factors Affecting Reliability and Useability of Aerial Photographic Target Interpretation

Table 3-15 relates classification to film format and flying height.

Target Encoding Error

It is possible for the interpreter to encode the same target more than once or not encode a target at all. All film interpretation procedures have this practical problem. With side-lap coverage (two-cameras), the problem may be compounded since the interpreter must look at two rolls of film to avoid making errors. Procedurally since side-lap is constant, one roll can be fully interpreted and the parallel roll partially interpreted. End-lap

occurs from frame to frame within a roll and errors are probably avoided although still possible. Vertical complete coverage (9" x 9") has end-lap coverage.

Mis-Coding Values

Illegal value entry is detectable, however inappropriately entering a legal value cannot be prevented. Feedback and prompting on the Orion are the means used to minimize this problem so common in processes employing coding sheets and keypunching.

Film Handling Errors

Once the film has been positioned on the digitizer tablet it must not be moved. If it has been moved the XY target location will not be correct when related to a geo-reference system. Secondly, if the operator fails to initialize a new frame, then targets being digitized will be associated with the previous frame's ground control.

Positive Factors for Acquiring Aerial Photography (Recommendations)

Aerial photography provides a permanent record of baseline conditions. It can be re-examined again and again, extracting new information. Reliability studies can be conducted to estimate accuracy of interpretation methods. Used in conjunction with a digitizer or zoom transfer scope, new map products can be produced or updated. Aerial photography provides instantaneous coverage of wide and site specific areas simultaneously and quickly. Longitudinal (year-to-year) coverage permits monitoring of use and resource change phenomena. More frequent coverage provides more accurate assessment of temporal and type of use phenomena.

Positive Factors Improving Reliability and Useability of Aerial Photographic Target Interpretation (Recommendations)

Aerial photography provides instantaneous and complete study area coverage and it also provides information on many other phenomena, including use, distribution and density of use. The quality of this information is a given. By employing an Orion computer graphics system, Talos digitizer and Bausch and Lomb Zoom Transfer Scope, it has been possible to collect a good deal more than summary statistics normally derived. The procedures employed also considerably enhance the reliability of the data collected.

Handbook Development

The first purpose of the handbook is to record standard names for variables to be collected. These names improve communication among project personnel. Standard rules for variable interpretation are recorded for each variable. During processing,

the interpreter uses the handbook as a guide and also uses extra pages for each variable to note any special problems or insights. Early development of the handbook helps to identify adequacy of the data collection plans to answer study questions. When the project has concluded, the handbook is a complete source book for everyone attempting to comprehend exactly what was done and how it was done. The handbook is an absolute requirement to process the data base, since it also records legal values and their meaning. This information is important for statistical analysis and software development.

Orion System and Software

The use of the Orion system and associated software greatly minimizes the multiple sources of error attributable to coders, keypunchers, IO clerks and the delays of batch computing. Furthermore, the structure it provides to the process greatly increases the amount of information reliably collected.

This approach utilized software to control, verify and display data entry options. The control process included prompting for each field to be entered and providing a list of values and their meaning. When an illegal entry is made the operators must re-enter a legitimate value. Numerous check-points are provided to go back several steps to correct inappropriate but legitimate data entry when noticed. The interactive nature of this process encouraged collection of information about confidence and certainty regarding interpretation decisions. This information is critical to reliability studies that were made.

The Orion system also contains a floppy disc system upon which all collected data are written. Thus, the collected data are immediately in machine readable form and ready for analysis as soon as they are transmitted to a main frame computer. Such information analyzed in an on-going manner is important feedback to direct and control the interpretation process. The Orion can also make a copy of one disk from another, thus preventing any accidental data loss by creating a backup.

Zoom Stereoscope/Talos Digitizer/Orion System

The Zoom Stereoscope is used to scan and enlarge film placed on the digitizer surface. Without the ability to magnify the image, classification of target types is very crude (barges and other). However, it is from the combined use of these three pieces of equipment that the reliability, versatility, and volume of information collected is actually realized.

The use of control points for each film frame, where the operator locates points on the film frame that correspond to known points on USGS quadrangle maps, caused the image to be carefully examined. These same control points can be used to translate target locations to a geo-reference system such as latitude-

longitude. It is implicit that the XY location of each target in each frame is known and therefore the reliability of the entire process can be assessed just by repetition. It is also implicit that the relative spatial distribution of targets is known and becomes part of the machine readable record along with many other variables associated with the target.

ERROR ESTIMATES

Error Examples

Any data collection process, with its numerous stages of processing, is going to contain errors. These are of two types: (1) inappropriate interpretation and (2) mis-coding. Training handbooks and auxillary equipment using special procedures are means to minimize the former. Mis-coding can be greatly minimized by employing computer assisted data capture and entry.

It is understood that, without training, two interpreters will develop very different decision rules. The development of the handbook and its use as a record of problems and insights assures greater consistency among interpreters. The use of the TALOS digitizer and control points caused all images to be completely and carefully scanned.

Mis-coding really contains two sub-categories. The first relates to making a correct interpretation but providing a legitimate but different response. Very little can be done about this kind of error. The second category is seldom recognized but can be dealt with quite easily when using a system like the ORION, where software can be written to check data entry for being legitimate (specific values and ranges) and consistent with other data being entered.

Almost all variables were controlled in this manner. TARGET and RMILE were controlled to the ranged "00" to "99" and "000" to "999" respectively. Examination of Combined Frequencies Book 2, Part 1 reveals very few mis-coding errors. On page 42 of Part 1 of Book 2, one target has been classified as a "69" illegally since this code was not used. With appropriate cross tabulation the offending record can be located and traced back to the original film frame for correction. On page 44 of the same book, Part 1, illegal river mile values (RMILE) have been entered four times. Again, given the methods of data capture, these records can be located on film and in the data base for correction.

Another technique employed to detect mis-coding of both kinds is to cross tabulate inter-dependent variables. This should be planned into the handbook as a valuable error discovery technique. One example of this occurs in Book 7 on page 17 of Part 2. This is a cross tabulation of river mile by "dock targets" within the river mile 480 marina. The target class 31, "covered boat slip", was entered by the interpreter 46 times. This marina does not contain any covered boat slips. In this case it was possible to discover this problem because of the same data collected redundantly from other dates and by judicious use of cross tabulation.

Extremely low error rates have been achieved by integrating the data encoding process with machine readable record creation. The various equipment components have each played an important role in this accomplishment both in increasing the amount of information collected and the quality.

Target Confusion and Confidence Measures

The target confusion matrix in Table 3-14, a compilation based on interpreter experience, is indicative of the distinguishability between target types and the likelihood of a given target type being mis- or cross-classified. Instructions for use, definitive assumptions and conclusions follow with supporting evidence from the target/confidence/film type/attitude cross tabulations.

The following is a discussion of target distinguishability and likelihood of cross-classification (target confusion).

Assumptions: made in formulation of matrix in Table 3-16.

1. Decked hull and houseboats were subcategorized into small and large types for illustrative purposes, although only one generic target code exists, as indicated.
2. Entries relative to rowboats imply targets are stationary (i.e., not underway).
3. The last category (similarly sized/shaped objects) by definition, has no target code, but is significant in the distinguishability of targets in the context of size and shape.

Conclusions: see also the discussion on confidence measures which follows:

1. Distinguishability is directly related to target size.
   a. Targets of larger size are easily distinguished from other targets of similar large size, but different shapes.
   b. Targets of larger size are very easily distinguished from smaller size targets, given some frame of reference by which to judge scale visually.
   c. Smaller size targets become progressively more difficult to distinguish from other small targets unless gross differences in shape are discernable.
2. Indistinguishability of a given type target from other similarly sized/shaped objects not otherwise given a target code should decrease with increasing size.

Experience indicates that certain factors are correlated with interpreter confidence measures in target classification.

Target size/shape (part 1, Book 5): the larger the target and/or the more distinctive and unique its shape, the greater its confidence level in classification. Large watercraft (houseboats, barges, tows, excursion boats) and distinctively shaped targets (hunting blinds, docks, and boat slips) tended consistently to exhibit a high percentage frequency of "very sure" (01) confidence.

Reasons for lack of confidence (see part 1, Book 5): with the smaller targets, code 01 "shape/configuration not well defined" was the major reason for lack of confidence in the WHY1 through WHY4 series of variables. Aside from that, partial imaging due to tree canopy (code 06) was the only other significant reason for lack of confidence.

Flight altitude (see part 2, Book 5): combining the CONF "very sure" and "educated guess" categories together (codes 01 and 02, respectively), one finds no significant difference in the (overall high) confidence ratings based on altitude, considering that the two 3500' flights were the first to be targeted. This appears to hold true also for craft in the Rock Island Marina. The overall confidence at the 3500' altitude again appears lower than for either the 2500' imagery or the 9" x 9" imagery and again is accounted for in the "learning" process: the two 3500' flights were the first ones to have the RI Marina targeted. As the other lower altitude and the 9" x 9" imagery were targeted, a pattern in the marina slippage according to craft type and size had become evident resulting in the observed higher confidence levels in those categories.

Film type (see parts 1 and 2, Book 6): of the two dates (June 21 and August 15), when both normal color and color infrared 70mm film was used, there appears to be no significant difference in confidence levels based on film type. The apparent difference in confidence levels between the two dates is related more to the sequence in digitization (June 21 early and August 15 later) than to the differences in altitude.

Docks

Excluding the dockage in the RI Marina at river mile 480, a rather definite discrepancy was observed in the dockage along the rivers, as evidenced by the frequency by river and flight date shown in Table 3-17. The river miles marked with an asterisk (*) in the table were re-examined across all four flight dates simultaneously so that the factors contributing to such significant discrepancies could be determined. Certain conclusions were drawn from the re-examination:

1. New docks were being constructed through the course of the summer.

2. Towards the end of the summer and early fall, docks were being torn down or removed.

3. The presence of larger boats by the shoreline (but not beached) led to the presumption that they were docked at rather small docks hidden from view, usually in the general area where another dock or docks were visible.

4. Interpreter variability in photo interpretation criteria, as previously discussed, explains in part the inconsistency between interpreters (June 21 and August 11 by one, July 4 and September 15 by the other).

   It should be noted that the re-examination of all four flights simultaneously allowed inter-flight comparisons that were not part of the routine procedure during digitization.

5. Partial imaging of the shoreline at the lower altitude can result in the "loss" of docks.

6. Scanning oversight by the interpreter can result in missed targets.

Re-examination dock counts are shown in Table 3-18. Time for the re-examination was approximately six hours.

River mile 459: Two docks had been added over the course of the summer, one each between June 21 and July 4, and July 4 and August 15, and the removal of one between August 15 and September 15. The differences apparent in the table and not accounted for by addition and removal of docks was related to interpretative variability.

River mile 466: The addition of three docks between June 21 and August 11 was apparent. On the June 21 flight part of the shoreline along which five of the docks were located was not imaged. That and the construction of new docks later in the season accounts for the extraordinarly low count for that date. There is a hint of two new docks being built on July 4, but were detectable only because the September 15 imagery was being viewed simultaneously. Likewise for the August 11 imagery.

River miles 470-472: One new dock was evident, as was the removal of one, and that curiously enough, was found to be between August 11 and September 15. Interpreter variability, idle boats, and the presence of what appears to be similarly sized and shaped objects (such as fallen trees), introduce an element of

target indistinguishability and confusion into this area. The images, whether or not they are indeed docks, are essentially identical across all four flights.

June 21 Reliability Tests

As a test of the interpretation reliability and as a means to develop comparative time estimates of alternative methods of data capture two additional passes were made over the June 21 flight. In the first test (second run) all procedures were kept the same except that docks and empty slips were not encoded nor were control points. In the second test (third run) a strictly manual (hand) count of boat types was carried out. The results of these tests are tallied in Table 3-19. The June 21 data was the first data encoded. The first test was conducted eight weeks later. The second test was conducted about two weeks after the first test.

Some general conclusions may be drawn. There is no doubt that the most reliable procedure of the three is the original procedure, recording control points, docks and empty slips. This procedure is the most time intensive of the three but yields proportionately more information for that time investment.

The results of the original interpretation and the first test were quite inconsistent especially when compared by frame. The second test was conducted to determine the reliability of the first test method. It should be noted that, to remain objective, both tests were conducted without benefit of data from the other encoding passes. It should be noted that in making river mile judgements interpreters had to look away from the film and examine a USGS topographic quadrangle map upon which river miles were marked.

The second test confirms the results of the original procedure very closely. The only major difference between the original pass of the June 21 flight and the first test (other than the digitization of watercraft only) was the elimination of control points. This most likely resulted in less careful examination of the film images and accounts for most of the discrepancies. The other contributing factor is interpretative confusion between craft types (see target confusion matrix in Table 3-16).

TABLE 3-1 Personnel Requirements

Pilot

- single engine rated
- low altitude flight knowledge

Photographer

- two college level courses in photogrammetry
- knowledge of small format systems

Aerial Photography Manager

- basic librarian skills, indexing
- map reading skills

Computer Programmer/Systems Analyst

- knowledge of data structures
- experienced with graphics/digitizers
- experienced in on-line data collection
- knowledge of statistical procedures

Airphoto Interpreter

- natural resource background
- college level course in photo-interpretation

Clerical: Flight Line Data Entry

- typing ability

TABLE 3-2 Equipment Requirements

A. AERIAL PHOTOGRAPHY

1. Air Plane (single engine overhead wing with belly-hole)
2. Camera Mount (allow for oblique photography)
3. Two Motor Driven 70mm Hasselblad Cameras
4. Intervalometer
5. Exposure Calculator

B. INTERPRETATION

1. Small Light Table
2. ORION Computing System
3. Digitizer
4. Zoom Stereoscope

C. ANALYSIS

1. Main Frame Computer
2. Plotter

TABLE 3-3 Time Requirements for All Pools in Hours

	Initial[1]	Recurring[2]
A. Aerial Photography Planning		
1. Review and analysis of photogrammetric principles	100	0
2. Design of camera mount	80	0
3. Handbook codes for photography	80	0
4. Flight template preparation	10	0
5. Flight map layout and production (17 map pairs @ 5 hrs/map pair)	85	0
	355	0
B. Aerial Photography Acquisition		
1. Mission planning (14 missions @ 3 hrs/mission)	42	42
2. Acquisition of film and preparation (156 rolls for 51 flights)	20	20
3. Flight times (14 missions @ 110 hrs)	110	110
4. Preparation and conduction of 9" x 9" contract	50	50
5. Film processing shipment (14 missions @ 2 hrs/mission)	28	28
6. Flight log transcription (for data encoding purposes, 51 flights @ 1.5 hrs/flight)	75	75
	325	325
C. Handbook/Codebook		
1. Initial development	80	0
2. Adaptation and refinement	80	50
	160	50
D. Equipment Construction and Adaptation for Zoom Stereoscope		
1. Design	10	0
2. Construction and fabrication	40	0
	50	0

[1] Initial time values represent estimates to conduct the methodology as developed and operationalized.

[2] Recurring time values represent estimates to conduct the methodology again as operationalized. Estimates reflect all 12 pools.

		Initial[1]	Recurring[2]
E.	Preparation for Aerial Photography Interpretation		
	1. Map and mylar preparation	10	0
	2. Film numbering (10 min/roll)	25	25
	3. Conformance check with flight logs (10 min/roll)	25	25
	4. Screening for partial imaging, lack of endlap and/or sidelap (20 min/roll)	50	50
		110	100
F.	Operator and Interpreter Training		
	1. Use of mini-computer	60	0
	2. Use of digitizer	48	0
	3. Use of zoom stereoscope	12	0
	4. Method checkout and review	120	0
		240	0
G.	Software Development (Fortran/Assembly)		
	1. Utility software for ENTER and BDIGITIZ	40	0
	2. Disk IO (Input/Output) software for ENTER and BDIGITIZ	30	0
	3. Digitizer related IO software for BDIGITIZ	10	0
	4. Development of SENDMS data transfer software	45	0
	5. DISPLAY software (2 programs)	35	0
	6. ED60R7 software	10	0
	7. ENTER - driver for flight log data	50	0
	8. BDIGITIZ - driver for target encoding	50	0
		270	0
H.	Data Entry		
	1. Flightline data entry	120	120
	2. Flightline data book	30	30
		150	150
Total time to develop and operationalize methodology		1660 hrs.	
Total time to re-operationalize methodology			625 hrs.

TABLE 3-4 Time Requirements for Initial Aerial Photography Interpretation Tasks for Pool 16 in Hours[1]

	Initial	Recurring
Aerial Photography Interpreted for Pool 16		
1. Equipment set-up	11	11
2. Target interpretation	134	134
3. Target maintenance	20	20
4. Equipment tear down	13	13
	178	178
Data Transfer		
1. Transfer of ORION data to 1180	17	17
	17	17
Data Analysis		
1. Statistical	50	20
2. Graphic	70	40
	120	60
Total time to initially interpret Pool 16	315 hrs.	
Total time to re-interpret Pool 16		255 hrs.

[1] Initial time includes the amount of time to interpret, data transfer and data analysis for six flights in pool 16, given our environmental conditions. In respect to interpretation for example, a dedicated and secure environment for the machinery would reduce equipment set up and tear down time needs.

TABLE 3-5 Flight Time Requirements for Pool 16
(not including contracted 9" x 9" photography)

Item	Flight date				
	21 Jun	4 Jul	12 Aug	15 Aug	15 Sep
Transit time:					
to/from river	2:35	2:00	3:05	2:50	2:25
interpool	1:25	1:30	1:05	2:25	1:20
Photographic time:					
Pool 16	0:30	0:30	0:40	0:40	0:45
other pools	1:55	1:25	0:35	2:05	1:30
Ground time:					
refuel/film change	1:00	0:40	0:55	2:15	0:55
weather wait	-	1:35	-	-	-
Total time	7:25	7:40	6:20	10:15	6:55
No. frames in flight (Pool 16)	110	116	200	208	206
No. rolls film (Pool 16)	2	2	4	4	4

TABLE 3-6 Time Required to Interpret Aerial Photography for Pool 16 in Minutes

Flight Date	Equipment Set Up[1]	Target Interpretation[2]	Target Maintenance[3]	Equipment Tear Down[4]
June 21	75	1335	100	75
July 4[5]	165	2220	200	165
Aug. 11	15	955	285	100
Aug. 12	160	1975	170	170
Aug. 15	124	841	274	59
Sept. 15	138	692	176	182
Total in minutes	677	8018	1205	751
Total in hours	11.3	133.6	20.1	12.5

[1] Equipment Set Up. Includes removing equipment from security cabinets, setting up zoom stereoscope, turning on machines and organizing and getting film in position as many times as necessary to complete each flight since it could not be accomplished in one session.

[2] Target Interpretation. Includes deciding the target type, digitizing control points, locating and mounting quad mans, identifying control points, labeling control points, and encoding information about the target. Target interpretation includes only the actual time interpreting and encoding targets. Does not include any break time, interruptions, etc. This estimate must be viewed as being the minimum amount of time needed to accomplish this task.

[3] Target Maintenance. Includes copying files, editing files and miscellaneous operations.

[4] Equipment Tear Down. Includes re-storing of equipment, dismantling zoom stereoscope and re-organizing film.

[5] During the interpretation of this flight there were operator failures due to filling of a disc.

TABLE 3-7 Average Time per Target for Pool 16 (in minutes)

Flight Date	Altitude in Feet	Film Format and Type	Marina Partially Imaged	Total Target Interpretation in Minutes	Number of Targets per Flight	Average and Per Target Interpretation Time in Minutes
June 21	3500	70mm (2448 and 2443)[1]		1335	424	3.15
July 4	3500	70mm (2448 and 2443)		2220	799	2.78
Aug. 11	12000	9" x 9" 2443		955	609	1.57
Aug. 12	2500	70mm (2448 and 2443)	*	1975	593	3.33
Aug. 15	2500	70mm (2448)	*	841	515	1.63
Sept. 15	2500	70mm (2448)		692	733	.94

Average Time per Target 2.23 minutes

Or approximately 134 hours for the interpretation of 3673 targets

[1] Film 2448 is color positive transparency film and 2443 is color infrared positive transparency film.

TABLE 3-8 Costs for Aerial Photography Planning for all Pools (in 1979 dollars)

	Initial	Recurring
1. Fabrication of Camera Mount 655 to provide for oblique photography	655	0
2. Flight Line Planning Maps (includes photoreduction of Navcharts, mosaicing negatives, production of mylars)	300	0
3. Printing of Maps	50	0
4. Ground Control Maps (53 in total)	155	0
	$1160	0

TABLE 3-9 Cost for Aerial Photography Acquisition for all Pools (in 1979 dollars)[1]

	70mm Photography (51 pools)	9 x 9" Photography (12 pools)
A. Film		
1. 2443 IR (20 rolls @ 20.10/roll)	400	
2. 2448 Color (136 rolls @ 14.20/roll)	1930	
	2230	
B. Processing		contract consisted of film, processing and aircraft rental
1. 156 rolls @ 15.00/roll	2340	
	2340	
C. Air Craft Rental		
1. 110 hrs. @ 50/hour	5500	
	5500	
	$10170 for 51 pools, or $199/pool	$4800 for 12 pools, or $400/pool

[1] To reconduct all flights will vary upon the cost of the aircraft rental and film costs reflect bulk purchases before recent rise in film cost due to the rise in the price of silver.

TABLE 3-10 Costs and Characteristics of the Target Data Collection and Interpretation System (in 1979 dollars)

ORION 60/S4 Computer System	$ 17,025
- Touch Panel (tactile input) - 56K Memory - RS232C Interface - Plasma Graphic Display - Rear projection of images on display - 8" diskette floppy drives (2-250k bytes each) - Expandable options	
GANDALF LDS-120's	300
Link to large mainframe and tele-communications networks	
TALOS Rear Projected/Back Lighted 60" x 44" Digitizer	9,085
Bausch and Lomb Zoom Stereoscope	3,057
	$ 29,467

or, assuming a 60 month useful life @ 172 hrs/month, the per hour cost to use the system is: $2.85/hr.

TABLE 3-11 Costs for Data Entry and Analysis for Pool 16

	Initial	Recurring
A. ORION Computing System[5]		
1. Target Interpretation and Transfer	1668	770
	1668	770
B. UNIVAC 1100/80[1]		
1. Data Transfer	300	300[2]
2. Statistical Analysis	300	150[3]
3. Graphics	300	250[4]
	900	700
Total Cost for Target Interpretation, Transfer and Data Analysis	$2568	
Total Cost to Reconstruct Similar Study		$1400

[1] Costs are for University of Wisconsin-Madison Academic Computing Center and also included fixed file charges.

[2] Constant per case.

[3] Major cost associated with printing.

[4] Less likely to be standardized.

[5] This is based upon a 60 month useful life @ 172/hrs./month.

TABLE 3-12 Per Target Costs for Pool 16 (in 1979 dollars)

Flight Date	Altitude in Feet	Film Format and Type	Flight Time	Flight Time Costs	Film Costs	Film Processing Costs	Photography Costs Total in Dollars	Number of Targets per Flight	Per Target Costs per Flight
June 21	3500	70mm 2448 and 2443	30 min.	$25	34	30	89	424	.21
July 4	3500	70mm 2448	30 min.	25	28	30	83	799	.10
Aug. 11	12000	9" x 9" 2443	12 min.	NA	NA	NA	320	609	.53
Aug. 12	2500	70mm 2448	40 min.	33	57	60	150	593	.25
Aug. 15	2500	70mm 2448 and 2443	40 min.	33	69	60	162	515	.31
Sept. 15	2500	70mm 2448	40 min.	33	57	60	150	733	.21

Average per target cost, excluding August 11: .22

Average per target cost, including August 11: .27

[1] Film 2448 is positive color transparency film and 2443 is color infrared positive transparency film. 70mm estimates do not include the cost of the mount or flight map preparation.

[2] Flight time costs do not include transit time between airport and pool 16. August 11, 9" x 9" flight was contracted. The time was calculated for the August 11 flight on the basis of 3 hrs. total flight time.

TABLE 3-13 Air Photo Errors vs. Flight Date
(errors typical of those affecting interpretability)

Error Type	Flight Date/Circumstance
Partial Imaging	(Pool 16) August 12, August 15 (RI Marina) June 21 (RM 466 area)
Gaps in Endlap/Sidelap	Sidelap gaps incidental in most of 2500' photography (traceable to template design error)
Exposure Setting	May 26 (underexposed color IR) for Pool 13
Camera Failure (batteries)	May 28 (Pools 16 and 21) June 21 (Pool 21)
Non-synchronous Exposures	May 28 (Pool 16)
Flight Line Template Design	All 2500' Flights - pass width too wide

TABLE 3-14. Acquisition/Interpretation Suitability Matrix for Format System vs. Operational Factors

OPERATIONAL FACTORS			9" x 9" f=6 in.	(2x) 70mm f=40mm t=19°	(2x) 35mm f=24mm t=16.6°	(2x) 35mm f=50mm t=17.5°
ATMOSPHERIC FACTORS	TURBULENCE	Little or no turbulence	1	1	1	1
		Severe turbulence	1	2	2	3
	HAZE	Light haze	1	1	1	1
		Extreme haze	2	2	3	3
	CLOUDIMESS	Clear	1	1	1	1
		Scattered	1	1	1	1
		Broken	2	2	2	2
		Overcast	3	2	3	3
	WIND	Still or light	1	1	1	1
		Stiff	1	2	2	3
Ease in attaining 100% aerial coverage			1	2	2	3
Degree of redundancy in forward endlap			1	2	3	3
Minimizing multiple boat counting			1	2	3	3
Stereoscopic viewing			1	3	3	3
Viewing under tree canopies			3	2	2	2
Minimizing of flight time			1	2	3	3
No. of exposures required at same flying height			1	2	3	3
No. of flight lines required at same flying height			1	2	2	3
System Resolv. Power for all Watercraft at Indicated Altitudes		1500 Ft. AMT	1	1	2	1
		2500 Ft. AMT	1	1	3	1
		3500 Ft. AMT	1	2	3	2
		4500 Ft. AMT	1	3	3	2
		>4500 Ft. AMT	1	3	3	3
Minimizing overall film viewing complexity			1	2	3	3

TABLE 3-14.

LEGEND:
1 Appropriate (High Reliability - Minimal Deviation)
2 Marginally Appropriate (Moderate Reliability - Acceptable Deviation)
3 Inappropriate (Low Reliability - Unacceptable Deviation)
? Unknown

TABLE 3-15 Classification Reliability Matrix for Format/Photo Scale vs. Boat Type

	9"x9" (f=6in.) scales in fpi				70mm (f=40mm) scales in fpi				35mm (f=24mm) scales in fpi			
Boat Type	<1000	1000-2000	2000-3000	>3000	<1000	1000-2000	2000-3000	>3000	<1000	1000-2000	2000-3000	>3000
Canoe	1	1	2	?	1	1	2	3	1	1	?	?
Rowboat	1	2	3	?	1	2	3	3	1	2	?	?
Inflatable	1	1	2	?	1	1	2	3	1	1	?	?
Sailboat	1	1	1	?	1	1	1	2	1	1	?	?
Open-hull (powered)	1	2	3	?	1	2	3	3	1	2	?	?
Decked (powered)	1	1	1	?	1	1	1	2	1	1	?	?
Pontoon (powered)	1	1	1	?	1	1	1	2	1	1	?	?
Houseboat (powered)	1	1	1	?	1	1	1	2	1	1	?	?
Barges	1	1	1	?	1	1	1	1	1	1	?	?
Tow only	1	1	1	?	1	1	1	2	1	1	?	?
Excursion Boats	1	1	1	?	1	1	1	1	1	1	?	?

LEGEND:
1 Appropriate (High Reliability - Minimal Deviation)
2 Marginally Appropriate (Moderate Reliability - Acceptable Deviation)
3 Inappropriate (Low Reliability - Unacceptable Deviation)
4 Unknown

NOTES: 70mm and 35mm setups imply two-camera oblique photography in which the photographic scale will vary across image. 35mm format system reliability based on use of 50mm focal length lenses.

Target Confusion Matrix

TABLE 3-16. Index of Target Distinguishability/Likelihood of Cross-Classification

CODE		01Canoe	02Rowboat	03Inflatable	04Sailboat w/sail	05Sailboat w/o sail	06Open-hulled boat	07Small decked hull boat	07Large decked hull boat	08Pontoon boat	09Small houseboat	09Large houseboat	10Barges (no tow)	11Barges and tow	12 Tow only	13Excursion boat	20Hunting blind	30Covered slip	31Empty slip	40Small open docking structure	41Large open docking structure	42Covered docking structure	44Commercial/industrial dock	4ACommercial/industrial dock
02	Rowboat	2																						
03	Inflatable	1	2																					
04	Sailboat under sail	2	2	1																				
05	Sailboat with no sail	3	2	1	2																			
06	Open hulled boat	2	3	2	2	3																		
07	Small decked hull boat	1	2	1	2	2	3																	
07	Large decked hull boat	1	1	1	1	1	1	1																
08	Pontoon boat	1	1	1	2	3	1	1	1															
09	Small houseboat	1	1	1	1	1	1	3	1	1														
09	Large houseboat	1	1	1	1	1	1	1	2	1														
10	Barges (no tow)	1	1	1	1	1	1	1	1	1	1													
11	Barges and tow	1	1	1	1	1	1	1	1	1	1	1												
12	Tow only	1	1	1	1	1	1	1	1	1	1	1	1											
13	Excursion boat	1	1	1	1	1	1	1	1	1	1	1	1	1										
20	Hunting blind	1	1	1	1	1	1	1	1	1	1	1	1	1	1									
30	Covered slip	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
31	Empty slip	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
40	Small open docking structure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						
41	Large open docking structure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
42	Covered docking structure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
44	Commercial/industrial dock	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
--	Other similarly sized objects	2	2	2	2	2	2	2	1	2	2	1	1	1	1	1	2	1	2	1	1	1		

TABLE 3-16.

Interpretative Key:

1 high degree of distinguishability (low likelihood of cross classification)

2 moderate degree of distinguishability (moderate likelihood of cross classification)

3 low degree of distinguishability (high likelihood of cross classification)

Notes:

Matrix assumes photographic scale resolvability similar to that for our 70mm low oblique photography at altitudes of 2500' to 3500' AMT.

The dot symbol (·) indicates a single generic target code, hence no numeric entry.

Instructions:

Given two target types (including a similarly sized/shaped object category), the matrix entry indicates the degree of distinguishability, or likelihood of cross-classification.

TABLE 3-17. River Mile x Flight Date Crosstab for Small Uncovered Docks (excluding RM 480 Marina) (Target Code 40) (for the four fully-imaged RM 480 Marina flights)

River Mile	FLIGHT DATE (70mm) June 21	(70mm) July 4	(9 x 9) Aug. 11	(70mm) Sept. 15
458	1		1	3
*459	5	8	4	11
460		2	3	4
461				1
462	1	1	3	3
463	2		3	3
464	3	4	3	2
465	1	3	2	8
*466	3	9	9	11
467	3	5	7	13
468			3	8
469		3	3	2
*470			2	4
*471	3	2	6	13
*472	7	12	13	9
473	2			
474		2	2	
475				2
476	1	4	2	6
477		2	4	7
478		1		1
479			1	
480		3	2	4
481			1	

Note: River miles marked with an asterisk (*) were re-examined across all four flights simultaneously.

TABLE 3-18. Re-examined Small Uncovered Dock Counts

	June 21	July 4	August 11 (9" x 9")	Sept. 15
RM 459	count: 8 roll 67-015 frames 37-38	count: 9 roll 67-007 frames 40-42	count: 9 frame 87	count: 8 roll 64-403 frames 4-6
RM 466	count: 3 roll 67-015 frame 28	count: 10 roll 67-011 frame 32	count: 11 frame 84	count: 11 roll 64-408 frames 13-14
RM 470 - 472	count: 15 rolls 67-019 67-015 frames 20-24 20-24	count: 15 rolls 67-007 67-011 frames 22-27 22-27	count: 15 frame 82	count: 15 rolls 64-404 64-403 frames 30-32 20-26

Table 3-19
Interpretation Reliability
21 June Flight

TARGET TYPE

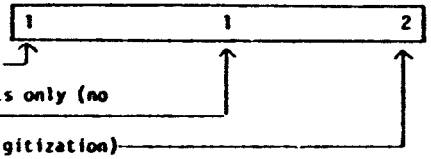
Orient	Frame	Canoe 01	Sailbt w/ Sail 04	Sailbt No Sail 05	Open Hull 06	Decked Hull 07	Pontoon 08	Housebt 09	Barge(s) 10	Barge(s) and Tow 11	Tow Only 12	Excur Boat 13	Frame Totals
1	1				1 1 2								1 1 2
	5				0 1 0								0 1 0
	6				0 0 1				1 1 1				1 1 2
	7				2 1 3	1 0 0							3 1 3
	8				6 0 5	1 0 1					1 1 1		8 1 7
	9				3 3 4								3 3 4
	12				4 4 5	0 0 1			2 0 2				6 4 8
	14	1 0 1			16 17 17	2 5 3		6 2 4					25 24 25
	19				3 2 3		0 0 1	1 0 4					4 2 8
	20	0 1 0			12 6 8	0 0 1		2 1 1					14 8 10
	21				1 2 2			1 1 1					2 3 3
	23				1 1 1								1 1 1
	24				1 1 1								1 1 1
	2		0 1 1	1 0 0									1 1 1
	4	0 1 1	1 0 0		0 1 1	1 0 0							2 2 2
	33				0 0 1								0 0 1
	34				1 1 1								1 1 1
	35				0 1 1					1 1 1			1 2 2
	37				1 0 2			1 0 0					2 0 2
	38				2 0 0	1 0 0							3 0 0
	50				1 1 1								1 1 1
2	3		0 0 1		1 1 0							0 2 2	1 3 3
	5					1 0 0		1 0 0		1 1 1			3 1 1
	6				0 0 1								0 0 1
	7				2 3 2								2 3 2
	8				1 2 0			0 1 0					1 3 0
	11								5 7 5				5 7 5
	18				1 5 2			0 0 2	7 7 7	4 3 4			12 15 15
	19				1 0 0	0 1 1		1 0 0					2 1 1
	21				1 3 2								1 3 2
	22								3 3 3				3 3 3
	25				4 0 4					1 0 1			5 0 5
	26									0 1 0			0 1 0

Table 3-19 (continued)

TARGET TYPE

Orient	Frame	Canoe 01	Sailbt w/ Sail 04	Sailbt No Sail 05	Open Hull 06	Decked Hull 07	Pontoon 08	Housebt 09	Barge(s) 10	Barge(s) and Tow 11	Tow Only 12	Excur Boat 13	Frame Totals
2	27		1 0 0		2 0 2	1 0 1							4 0 3
	29				0 1 0								0 1 0
	29				1 1 1								1 1 1
	30				4 1 5	1 0 0							5 1 5
	37				7 0 2								7 0 2
	38		1 0 1		4 1 3								5 1 4
TOTALS													
EXPERIMENTA		1 2 2	3 1 3	1 0 0	84 61 83	9 6 8	0 0 1	13 5 12	18 18 18	7 6 7	1 1 1	0 2 2	137 102 137
(R ISLAND EXPERIMENTA)		0 0 0	0 0 0	0 0 0	94 103 93	14 34 39	0 0 0	41 15 17	0 0 0	0 0 0	0 0 0	0 0 0	149 152 149

LEGEND:



Footnotes

1. Targets in frame 48 inadvertently missed in both second and third runs - the targets are imaged as indicated in first run.
2. Roll #2, frame #2: excursion boats simply were not noticed in first run. Also, the "open hull" boat was reclassed as sailboat, presence of sail determined on third run not discerned on first and second runs.
3. Roll #1, frame #10: two barges missed on second run and file was closed, but was aware of missed targets.
4. Roll #2, frames #25, 26, 27, 28, 28: suspect that during second run that the roll #1 frame numbers in FL 2 (LINK046), i.e., frames 26 and 28, were looked at in roll #2, thereby omitting the scanning of frames 25 and 27 and introducing extraneous frames (26 and 28) into the target record.

SECTION 4.

REQUIREMENTS FOR AERIAL PHOTOGRAPHY

TABLE OF CONTENTS - SECTION 4

	Page
REQUIREMENTS FOR AERIAL PHOTOGRAPHY	4-5
LOGISTICAL REQUIREMENTS	4-5
Personnel requirements	4-5
Pilot	4-5
Photographer	4-5
Aerial photography manager	4-6
Equipment requirements	4-6
Aircraft	4-6
Photographic system	4-7
Camera mount	4-7
Drawing/drafting system	4-8
Film storage	4-8
Film viewing	4-8
Dark bag	4-8
Supply requirements	4-9
Photographic film	4-9
Aerial exposure computer	4-9
Base maps for flight planning	4-10
Film packaging and shipping materials	4-10
Coastal and Geodetic Survey sectional charts	4-10
Miscellaneous drawing/drafting/filing supplies	4-10
Services Requirements	4-10
Photomechanical and engineering services	4-10
Weather forecasting and flight services information	4-11
Film processing	4-11
Contractual acquisition of aerial photography	4-11
Physical space requirements	4-12
ACQUISITION OF AERIAL PHOTOGRAPHY	4-12
Photographic scale	4-12
Format	4-13
Tilt	4-14

	Page
Flight maps	4-15
Selection of base maps	4-15
Use of flight maps	4-15
Layout of flight maps	4-16
Updating and revision of base maps	4-17
Timing of the aerial photographic mission	4-17
Time of year	4-17
Time of week	4-18
Time of day	4-18
Personnel constraints	4-19
Flexibility	4-19
Preparation for the aerial photographic mission	4-19
Photographic system	4-19
Film and film loading	4-20
Flight maps and flight logs	4-20
Aircraft	4-21
Weather and atmospheric condition compatability	4-21
Personnel comfort	4-21
Execution of the aerial photographic mission	4-22
Film magazine unloading/reloading and film labeling	4-22
On-site atmospheric conditions	4-22
Maintaining the flight log	4-23
Photographer/pilot communication	4-24
Supplementary (unplanned) photography	4-24
Contingencies	4-25
Film processing	4-25
MANAGEMENT OF PROCESSED AERIAL PHOTOGRAPHY	4-25
Imagery accession system	4-26
Imagery storage and retrieval	4-26
Imagery screening	4-27
Conformance with flight log	4-27
Frame number annotation	4-27
Imagery utility	4-27
APPENDIX 4.A	4-68
APPENDIX 4.B	4-75

LIST OF PHOTOGRAPHS, FIGURES AND TABLES

Photographs

		Page
4-1.	Cessna 180	4-28
4-2.	70mm Photographic System	4-29
4-3.	Camera Mount - front view	4-30
4-4.	Camera Mount - side view	4-31
4-5.	Camera Mount - bottom view	4-32
4-6.	Camera Mount and Photographic System in Use	4-33
4-7.	Dark Bag	4-34

Figures

4-1.	Belly-hole	4-35
4-2a-f.	Camera Mount Design	4-36
4-3.	Film Processing Shipping Label	4-40
4-4.	"Do not Expose" Label	4-40
4-5.	Film Type Label	4-40
4-6.	Field of View	4-41
4-7.	Geometry of Tilted Photographs	4-42
4-8.	Tilted Photograph with Square Ground Grid	4-43
4-9.	Tilted Photograph Auxillary Coordinate System	4-44
4-10.	Scale of Tilted Photograph with Ground Coordinate System	4-45
4-11.	Change in Scale in Tilted Photographs	4-46
4-12.	Two-camera Low Oblique Flight Line Template Elements	4-47
4-13.	Cross Sectional View of Oblique Pass Coverage	4-48
4-14.	Flight Line Template, H' = 2500' AMT	4-48
4-15.	Flight Line Template, H' = 3500' AMT	4-49
4-16a-c.	Pool 16 Flight Map, H' = 2500'	4-50
4-17a-c.	Pool 16 Flight Map, H' = 3500'	4-53
4-18.	Blank Flight Log Form	4-56
4-19.	Sample In-Flight Flight Log	4-57
4-20.	Sample Film Processing Request	4-58
4-21a-d.	Sample Transcribed Aerial Photographic Logs Sheets 1, 2, 3, & 4	4-59

Tables

4-1.	Kodak Aerial Films	4-63
4-2.	Image Resolvability	4-64
4-3.	Aerial Photography Record	4-65

REQUIREMENTS FOR AERIAL PHOTOGRAPHY

There are two major processes involved in obtaining the aerial photographic imagery and readying it for interpretative processing. The general tactical requirements under each of these processes are:

acquisition:	planning, flying, and film processing
management:	accession system, storage, and imagery screening

Logistical requirements for both acquisition and management are discussed prior to the two process-oriented sections.

LOGISTICAL REQUIREMENTS

Logistical requirements are broken down into five categories: personnel, equipment, supplies, services, and physical space. Contractual (as opposed to in-house) acquisition of aerial photography is discussed in the section dealing with services.

Personnel requirements

The three personnel requirements are: pilot, photographer, and aerial photography manager. Pilot and photographer requirements are based on in-house acquisition of the aerial photography. Reference to the masculine gender in the text in no way indicates sex as a constraining factor.

Pilot

The pilot must be single engine rated and should be locally based. Long-distance phone calls and, on occasion, scrubbed missions can result in strained relations between photographer and pilot. The pilot should be able to handle the aircraft at relatively low altitudes, where turbulent thermal air currents frequently buffet the aircraft, for the major portion of a flying day (six to ten hours), with refueling stops as necessary, without physical fatigue to the point of compromising flight safety.

Photographer

The photographer must have a basic working knowledge of photogrammetry, at least in the areas of photographic scale, flight planning, the use of small format photographic systems, and film characteristics. He should also be locally based, for reasons similar to those for the aircraft pilot, and must be able to adapt to the spatial disorientation phenomena characteristic of low altitude, highly maneuvered flight in light aircraft and perform his photographic task reliably.

Aerial photography manager

There are no highly specialized requirements, but the photographer is a logical first choice for this position, availability and time permitting. A basic familiarity with map reading and air photo interpretation is recommended.

Equipment requirements

Equipment requirements are broken down into specific sections: aircraft, photographic system, camera mount, drawing/drafting system, film storage, and film viewing.

Aircraft

A contractual (rental availability) agreement for aircraft and pilot is highly recommended, if the capability does not exist in-house. The aircraft should be a light, single engine, overhead wing aircraft with belly-hole, similar in nature (cabin size, cruising speed and distance) to the Cessna 180 (pictured in photo 4-1) used in this project. The four-hour cruising capability of the Cessna 180 was sufficient for our logistical requirements. Cabin size should permit seating of the photographer (facing either forward or backward) and storage of photographic equipment. The belly-hole should be centrally located, permitting the forward or rear-faced seating of the photographer. With an open belly-hole (the configuration of our flights) the photographer should sit forward of the belly-hole to minimize direct inhalation of incoming exhaust gases. No serious problem of this type occurred during the course of our flights, but the previous experience of others seated aft of an open belly-hole suggests discretion in this area. If the belly-hole is to be closed (windowed) under operational conditions, the use of safety plate glass is recommended to minimize scratching. This might be necessary if photographer tolerance to exhaust gases is low or for (cold) seasonal conditions where precious cabin heat must be conserved. In all cases a removeable plexiglas window (easy in - easy out) should be available for insertion into the belly-hole when the aircraft is in transit to and from the site and during all take-offs and landings. The overhead wing permits wider view span of the ground for the photographer to relate the flight map to object space, a severe operational deficiency in the use of bottom-mounted wing aircraft. Along the same line, the greater the window space available, the easier the visual orientation process. It is significant to note that the belly-holes in different aircraft may differ dimensionally, such as in the two aircraft available for our project (a Cessna 180 and a backup Cessna 310). The important consideration, further discussed in the section on the camera mount, is for the belly-hole diameter-to-depth ratio is to be at least 3, preferably greater than 4, so as to accommodate greater camera tilt angles necessary for efficient two-camera oblique coverage without the lenses protruding below the plane of the aircraft skin, illustrated in figure 4-1.

Photographic system

The photographic system components are: camera body, film magazine, lens, filter, and intervalometer. The two formats used in the project were 9" x 9" (contract flight) and 70mm (available in-house). Although a viable alternative for narrower rivers, the 35mm format was not practical for this study. The system, as used, consisted of twin Hasselblad 500 EL/M (motor driven) 70mm cameras using Distagon 40mm wide angle lenses, Hasselblad 70mm x 15' cassette (70 exposure maximum) film magazines, haze (or skylight) and #12 yellow filters (depending on film type used) and a four-channel intervalometer calibrated in whole second intervals from one to ninety-nine seconds. Under operational conditions, the intervalometer must have a range extending to at least thirty seconds, have a frame counter, and service at least two cameras. The filters serve a lens-protectiv function as well as reducing the ultra-violet radiation reaching the film. A bank of six to eight 70 exposure magainzes, available in-house, was adequate in terms of the logistics of magazine loading/unloading in-flight or during refueling stops. Wide angle lenses, although sacrificing image resolution in terms of the resolution cell size, permit more efficient areal coverage at a given flight altitude. The 70mm system is shown with one of the Hasselblad cameras exploded into its component parts in photo 4-2. Having a third (backup) camera and lens is advantageous should malfunctions or breakdowns occur, as happened twice during the early summer flights.

Camera mount

The camera mount must be designed to "fit" the aircraft or aircrafts to be used. The variable tilt design used for the Cessna 180 and backup Cessna 310 is shown in figure 4-2. The mount is shown with cameras in-place in the laboratory in photos 4-3, 4-4 and 4-5, and in-use in the Cessna 180 in photo 4-6. Referring back to figure 4-1, it is evident that the degree of camera tilt attainable (unobscured by the belly-hole flange) decreases as the belly-hole diameter-to-depth ratio decreases. However, the belly-hole can and most likely will vary from aircraft to aircraft, so the mount must essentially be custom-designed. The conceptual design of the mount is adaptable to any configuration. Its major features are as follows:

Variable tilt: the camera mount may be "fine tuned" to the maximum attainable tilt in-place in the aircraft(s) of choice after construction. Three tilt settings, at two-degree intervals, on either side of the estimated maximum tilt, based on belly-hole dimensions and the camera system used, should easily accommodate the maximum tilt when "tuned" in-place. For example, using masonite/wood belly-hole models (diameters of 16 and 14 inches, depths of 5 and 4.25 inches, and consequent ratios of 3.2 and 3.3, for the Cessna 180 and 310, respectively), 20° was the estimated maximum degree of tilt from the vertical. The mount was designed with tilt settings of 15, 17, 19, 21, 23 and 25 degrees, with placement on the mount

plates such that the lenses would not protrude below the plane of the arcraft outer skin. The maximum tilt attainable with the mount after placement in the Cessna 180, was 19°, indicating the utility of the variable tilt design.

Vertical orientation: two vertical position placements allow use of a two camera (and with minor modifications, a four camera) bank for multiple channel photography.

Crab correction capability: plus or minus 20 degrees of correction for carb permits more efficient areal coverage in a cross-wind.

Detachable camera brackets: individual brackets (designed for the Hasselblad 70mm system only) allow change in tilt and fitting for multiple aircraft.

Drawing/drafting system

A backlighted drawing surface is necessary for flight man compilation and flight planning. Other specialized drafting equipment is not necessary, only straight edges, triangles, and measuring devices (rulers).

Film storage

Refrigerated (frozen) storage is required for unexposed film to extend its shelf life. The freezer compartment of a conventional refrigerator should be adequate. Processed film should be maintained in an easy access-retrieval filing system arrangement. Recommended for 70mm film is the upright computer card filing cabinet.

Film viewing

A light table (portable or fixed) with spool holders, winding arms and rollers is necessary for screening of the processed film. The capacity to view two rolls of 70mm film simultaneously is recommended. The film viewing system as described in the section on interpretative processing may be used if the digitizer is not otherwise in use.

Dark Bag

The dark bag (shown in use in photo 4-7) is a double shell bag (opaque to light) used for loading and unloading the photographic film, both on the ground and in-flight, in total darkness. The bag is sized and shaped somewhat like a neckless T-shirt, with two elasticized arm holes, or sleeves, and a double-zippered opening at the bottom. The inner and outer shells are independent of each other, connected only at the sleeve openings, and the zippers close in opposite directions. Tears in the shells must be repaired by sewing or taping. It is recommended that a backup bag be available in storage if needed.

Supply requirements

Categorically, supplies are both major and trivial cost items. The photographic film can represent the single greatest cost item in the area of supplies if the project is at all large in scope or long term. Other necessary items are base maps for compiling flight maps, an aerial exposure computer, film packaging and shipping materials, USCGS sectional charts and miscellaneous drawing, drafting and filing supplies.

Photographic film

As mentioned, film can become a big-dollar item. In addition it requires foresighted logistical planning. Kodak is essentially the only manufacturer of aerial films, and aerial film differs from conventional over-the-counter film in its color balance. When purchased in bulk form (i.e., large rolls) it is frequently available from regional vendors. However, this requires the additional purchase of many empty film cassettes and a bulk film loader, and is operationally practical only when larger capacity film magazines than the 70 exposure ones recommended must be used. 70mm x 15' (roll length) pre-packaged film cassettes were special ordered from Kodak's Rochester, New York, facility through their (Chicago) Professional Products Customer Service, which, in turn, was placed directly by our local vendor (a Kodak requirement). Minimum time required to fill a special order of this nature with Kodak is normally forty-five days, and the order must be of a minimum quantity of approximately one gross line items. We found that the special order's "per roll" cost was competitive with locally available bulk roll film

Table 4-1 relates in matrix form the relative advantages of the various aerial films available from Kodak (1978). Our use was limited to the use of Type 2443 Color Infrared (70mm) and Type 2448 Normal Color (70mm). Both were used as pre-packaged 70mm x 15' cassettes and require special ordering. As many empty cassettes as there will be magazines used (six to eight) must also be purchased for film take-up.

Aerial exposure computer

A cardboard aerial photographic exposure computer, known as the "R-10 Aerial Exposure Computer," is available from Kodak (catalog no. 156 627?) through most vendors, and is quite inexpensive relative to its value in computing proper exposures given solar altitude, aircraft altitude, aerial film speed, and haze condition. Some infrared imagery was underexposed early in the summer, for need of such a computer, representing the sum of flight, film, processing and personnel time costs lost to the utility of the project.

Base maps for flight planning

A uniform base map system is required from which to compile flight maps. The functional aspects are discussed in the section on flight maps. The Corps of Engineers navigation charts (scale: 1" = 1/2 mile) for the Upper Mississippi River were the logical choice for flight base maps for this project. Depending upon the project, USGS topographic or planimetric maps, county highway maps, or other similarly scaled and detailed maps may be in order.

Film packaging and shipping materials

Required are sturdy corrugated cardboard boxes, ranging in size from approximately one-fourth to one cubic foot, depending on the size of the film shipment to the processor, lightweight foam and/or plastic bubble packing material in small quantities, strapping tape, and certain labels that should be available from the custom processor, such as Precision Photo Laboratories, Dayton, Ohio, the lab used for our processing needs. The labels are pictured in figures 4-3, 4-4, and 4-5. If not available from the processor, similar labels should be locally made, since all the labels serve important functions. Once processing begins, the returned shipping boxes, provided they were sturdy to begin with, can and should be recycled through several shipments.

Coastal and Geodetic Survey Sectional Charts

The pilot will need sectional charts of course in his flight planning and he should be responsible for their availability.

Miscellaneous drawing/drafting/filing supplies

An array of typical supplies, usually readily available and suited to the tastes of the people or departments involved, are too numerous to mention in detail except for one particular item, 1/4" or 5/16" signal dots, used to mark flight lanes and individual frames on the processed imagery without damaging it.

Services requirements

Services include those activities which are necessarily outside the in-house expertise or that may be beyond the available in-house resources. They include photo-mechanical and engineering services, weather forecasting and flight services information, film processing, and (if project objectives so require), contractual acquisition of high-cost large format aerial photography.

Photomechanical and engineering services

Mosaicing and photoreduction of the Corps of Engineers' river navigation charts for flight base map production required this

specialized service, and periodic blue (or black) line prints of these base maps from time to time was also required. Much in the area of drawing and drafting supplies should also be available.

Weather forecasting and flight services information

The local U.S. Department of Commerce NOAA weather service office provides valuable long range and short term weather prognostications on demand (normally the forecasters can be reached after the "recording" is completed). A significant drawback is the time of day availability of the NOAA offices, usually only about nine hours during the business day. Of somewhat greater utility, but technically limited to access by pilots, is the local/regional flight services office, available around the clock with up-to-date weather and related flight briefings. Access to such a service is imperative for planning purposes and the last-minute decisions that oftentimes must be made, especially with the large regional coverage typified by this project. The pilot and photographer together agree on the details of each flight or series of flights based on this information.

Film processing

Because of the nature of the investment of time and money into an aerial photographic capability of the sort herein described, film processing is best left to the custom laboratory, such as Precision Photo Laboratories, Dayton, Ohio, the service used for this project. The custom lab should provide reliable, high quality demand service tailored to the processing request. It should also be able to furnish shipment labels such as those depicted in figures 4-3, 4-4, and 4-5. A blanket purchase order, as used for this project, with the processing service is highly recommended.

Contractual acquisition of aerial photography

As was required in this project, contract flights to obtain 9" x 9" imagery require a specialized service. The capital investment required to conduct this large format aerial photography is prohibitively high for all not commercially or statutorially involved in providing this service. The Manual of Photogrammetry of the American Society of Photogrammetry provides an ideal reference source for writing bid specifications for such services. The Request for Quotation and Bid Specifications for this project's 9" x 9" contract flight are found in Appendix A. Appropriate bid response times must be allowed for in scheduling of such flights. As can be noted in the accompanying bid specifications the "time of photography" spec did not allow for a sufficiently long total lead time (i.e., from drafting to awarding of contract) to allow for photography on the weekend following July 4th, the original target date. The drafting process began in mid-May, but for a number of reasons related to fiscal control, the invitations to bid were not ready for distribution until early July, thus illustrating the logistical leadtime required in this area.

Physical space requirements

Spatial requirements are not great in terms of floor space. Most important are the concepts of security and co-location of processed film storage with the screening and interpretive equipment (see REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING). Security is important because of the high dollar investment and irreplaceability of the imagery at this point. Limited access to the imagery itself, as well as the area in which it is stored, is important. Co-location with the interpretative equipment both expedites security (of film and equipment) and promotes efficiency in the screening and interpretative processes. Security is also needed for unexposed film storage, the photographic equipment, and camera mount, though it need not be co-located with film storage or interpretative equipment. The darkroom is simply a small area (e.g., a closet) needed for film loading prior to a mission if bulk film loading is required. Otherwise it is not a requirement, since the dark bag is used for loading and unloading film cassettes in the magazines. Since upright cabinets are perfectly adequate for most all film storage needs, only minimal floor space is required. A backlighted drawing table and film viewing apparatus also requires a minimal amount of floor space. If all operations and storage (including interpretative requirements, 500 to 600 ft^2 of floor space should be adequate, provided it is a secureable, minimum traffic area).

ACQUISITION OF AERIAL PHOTOGRAPHY

Acquisition covers the planning and flying of the aerial photographic mission and processing of the film. The first two tasks are further defined:

Planning:	photographic scale, flight maps, and timing of mission
Flying:	preparation and execution

Photographic scale

Knowledge of the mathematics of photographic scale is imperative in aerial photographic flight planning. The approximate scale of a vertical photograph is relatively simple to conceptualize and compute, given the camera lens focal length and flying height over essentially flat terrain. The scale of a tilted photograph, even over flat terrain, varies with the distance normal (perpendicular) to the axis of tilt, and is conceptually more difficult to grasp. Format is addressed first to set the framework for the discussion of tilted photo scale which follows, and which forms the basis for planning of the low oblique aerial photography used in this project.

Format

To discuss the interrelationship of photographic scale and format, two areas are of interest: field of view and resolvability.

Field of view is characterized by the angle subtended or "seen" by the camera lens. It is dependent only on the lens focal length and film format (see figure 4-6), and is independent of camera orientation. As the flying height increases (assuming a fixed camera orientation) the area in object space (i.e., the earth's surface) seen within that field of view becomes proportionately greater, thus decreasing the photographic scale. The computational formula for photographic scale is based on the geometry of similar triangles. For the vertical photograph it is:

$$S_{avg} = \frac{f}{H-h_{avg}}, \quad \text{or} \quad S_{avg} = \frac{f}{H'_{avg}} \qquad (i)$$

where S_{avg} is the average photographic scale in terms of photo distance per unit of object space (horizontal ground) distance, f is the lens focal length, H is the flying height above datum (normally mean sea level) approximated by the aircraft altimeter, h_{avg} is the average elevation of the terrain, and H'_{avg} is merely the flying height above datum less the average terrain elevation, or in other words, the flying height above mean terrain (AMT). The photographic scale itself is independent of the format, but the format and field of view, because of their relationship to the areal coverage on the ground at a given scale play a significant role in determining the significance of a third concept, that of image resolvability.

Image resolvability is technically expressed in terms of the number of line pairs (of contrasting black and white bands) per unit (photo) length just barely resolvable, or detectable. Operationally it expresses the minimum size an object must be to be capable of being resolved, or detected, on the imagery. The lens, film and filter in combination determine the image resolvability. The film, given high quality equipment, would be expected to be the weakest link, but the gradual accumulation of a thin film of engine oil and atmospheric dust on the lens filter, or belly-hole window, as appropriate, probably compromises image resolvability a bit further than that claimed by Kodak for the film under low contrast image conditions. This compromise was consistently experienced in our flights and can be expected to occur elsewhere. If resolvability at a certain level is required for a given format and field of view, the minimum photographic scale is determinable, which in turn determines the flying height and areal coverage. Although outside our capability to test for under operational conditions (i.e., with an engine oil/atmospheric dust film on the filter), the best image resolvability can be guesstimated at or about 30 line pairs per mm (that of the Type 2448 and 2443 films under low contrast conditions is approximately 40 line pairs per mm). Assuming the figure of 30 line pairs per mm to be representative, Table 4-2 indicates the

resolution cell size at various photographic scales. Since the table's scale is expressed in feet of object space per inch of photo space (fpi), the convention of decreasing "fpi units" scale magnitude increases the magnitude of photographic scale as it is technically expressed in terms of units of photo measurement per unit of object space measurement. The "fpi units" are a somewhat more convenient and relateable means of expressing photographic scale. The resolution cell sizes expressed in Table 4-2 are irrespective of the vertical or oblique orientation of the camera(s) per se.

Tilt

Tilted photographs introduce a certain complexity to the conceptualization and computation of photographic scale. Very small (usually unplanned) degrees of tilt are often ignored, but in low oblique aerial photography where the magnitude of tilt is deliberate and sizeable, 19° in our case, the tilt cannot be ignored in the planning process. Imagining a tilted photograph in space, the basic geometry is depicted in figure 4-7. Looking at the same sort of tilted photo (but with a swing angle s of exactly 180°) on edge and the image of a square ground grid on that photo in figure 4-8 one can easily visualize the change in scale with perpendicular distance from the axis of tilt. This is the type of tilted photograph characteristic of our low oblique photography (in concept). The auxillary x'y' image coordinate system for a tilted photo is pictured in figure 4-9. Our low oblique photography is approximated by a θ angle (the angle defined by the y and y' axes) equal to zero degrees. Using geometry of similar triangles in a way only slightly more involved than for vertical photographs, as shown graphically in figure 4-10, the resultant equation for computing photographic scale on a tilted photograph for any point, say point A, whose elevation is h_A above datum, is:

$$S_a = \frac{\frac{f}{\cos t} - y_a' \sin t}{H - h_A} = \frac{Lk}{LK} = \frac{ka'}{KA'} \qquad (2)$$

where H is flying height above datum, f is camera focal length, t is the tilt angle, and y_a' is the coordinate of the point of interest in the auxillary image coordinate system, defined as follows (re: figure 4-10).

$$X'_a = X_a \cos \theta - y_a \sin \theta$$

$$Y'_a = X_a \sin \theta + y_a \cos \theta + f \tan t \qquad (3)$$

Equation (2) is important in computing the flightline pass coverage width w, discussed in the layout of flight maps. Figure 4-11 illustrates graphically for various flying heights H' (AMT), the relationship between photographic scale and the y distance from the photo principal point (noting that y and y' distances are one and the same for oblique photography of the nature planned for this project). For greater detail in the discussion of tilted photographs, refer to the Manual of Photogrammetry of the American Society of Photogrammetry and Elements of Photogrammetry by Paul Wolf.

Flight maps

Flight map compilation for low oblique aerial photography represents the application of the computational equations for photographic scale on tilted photographs, the practical aspect of image resolvability, and flight line design to attain adequate areal coverage while minimizing the number of passes required to attain that coverage. The base map selection, use, layout and updating/revision of the flight maps are discussed.

Selection of base maps

The Upper Mississippi River navigation charts (scale: 1" = 1/2 mile) were used to form the basis for the flight maps. They were chosen because of what was felt to be adequate planimetric detail at a scale and in a form to minimize the degree of mosaicing required to piece the photoreduced negatives together in terms of individual pools. The photoreduction was by a factor of two, yielding flight maps of each pool at a scale of 1" = 1 mile, large enough to maintain the utility of the planimetric detail for which the charts were chosen, yet small enough for both pilot and photographer (each with individual copies) to use successfully in very limited cabin space. The use of USGS or county highway maps would suffer from the necessity to piece together small pieces from corners of maps not otherwise useful and in the case of the USGS quads, from the nature of the conformal projection. The Cartesian projection of the river navigation charts was ideal for the relatively non-exacting purposes in flight map planning. An early attempt to use the navigation chart based flight map photoreduced to a scale of approximately 1" = 6 miles (fitting on an 8 1/2" x 11" size print) was futile. It was found that in addition to the advantages already outlined, the 1" = 1 mile scale visually approximated the geographic scale of the river while flying operationally at altitudes of 2500 to 5000 feet AMT, making both pilot's and photographer's sighting and orientation tasks much easier. The 1" = 1 mile scale is thereby recommended for flight map scale and the base map should not sacrifice detail or legibility when reduced (or enlarged) to very nearly that scale.

Use of flight maps

The annotated flight map serves two purposes: a means by which the pilot knows the sequence, direction, altitude and endpoints of each flight line for the purpose of visually sighting his flight vector. The photographer uses the map for essentially the same purposes as the pilot plus the on-off operation of the photographic system, annotation of the photographic flight log, and a means by which the photographer can estimate how much faster or slower than planned is the ground speed of the aircraft. It literally becomes both "road map" and "operational checklist" for the aerial photographic mission. During both the film viewing operation (see MANAGEMENT OF PROCESSED AERIAL PHOTOGRAPHY) and

the imagery interpretative function (see REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING), the flight maps, along with the flight logs, serve a useful and necessary spatial reference function.

Layout of flight maps

The master flight map base for each pool should be on mylar (the positive print from the photoreduced negative mosaic) from which blue or black line prints are made for layout of flight lines and associated information. The flight line "templates" are laid out, preferably on a sheet of mylar which underlays the flight map to be produced on a light table.

The template is produced by scaling the desired air base and pass coverage width to the altitude at which the photography will be flown. The air base depends on the degree of endlap desired along the flight line, photographic scale and format, whereas the pass coverage width is dependent on field of view, flight altitude and the degree of tilt. Computational equations are as follows:

for the air base B (see also figure 4-12),

$$B = dS_n (1-E) \qquad (4)$$

where B is the air base in feet, S_n is the photographic scale (expressed here in terms of fpi, the inverse of scale as computed from equation (2) at the supposed photographic nadir point, d is the format frame dimension in the direction of flight (2.18 inches for the 70mm format), and E is the percent endlap desired expressed as a decimal fraction, e.g., (1-E) = 0.8 for 20 percent endlap.

for the pass coverage width W (see also figures 4-12 and 4-13).

$$W = 2H' \left(\tan \left[\frac{\theta}{2} + t\right]\right) \qquad (5)$$

where W is the pass coverage width expressed in feet, H' is the planned flight altitude above mean terrain, $\theta/2$ is one half the angular field of view of the photographic system and t is the angle of tilt, both angles expressed in degrees.

Once the air base B and pass coverage width are computed, they are scaled to the flight map's scale (1" = 1 mile) and the template is drawn. Figures 4-14 and 4-15 represent the final form of two templates, one for H'=2500' AMT, the other 3500' AMT. The template is then used to lay out in pencil the flight lines "dog leg" fashion by trial and error until a satisfactory fit is obtained that meets the following criteria:

the film magazine changes occur between flight lines, not in the middle of one

the beginning and end of each flight line be somewhat redundantly covered by the end of the previous one and the beginning of the upcoming one

there be at least ten percent sidelap planned across parallel flight lines

there be at least ten percent sidewise coverage beyond the boundary of the resource to be imaged

After the fit is obtained, the flight lines are firmed in with pen, and the exposure track emphasized with a wide-tip highlighting marker for visual ease of use. The water surface should be colored in for clarity. The pertinent operational factors, flight line direction and sequence, flight altitude and bearings can also be annotated on the flight maps for encoding purposes in the imagery interpretative process, but are not necessarily of use to the pilot, since his primary means of setting the flight vector is by line-of-sighting down the nose of the aircraft using planimetric landmarks, such as tips of islands, bridges, road intersections, locking gates, etc. It is significant that the photographer producing the flight maps keep this in mind when fitting the flight lines. It makes both the pilot's and the photographer's jobs in flight much easier. Figures 4-16 and 4-17 show the finished operational flight maps for flight altitudes of 2500 feet and 3500 feet AMT, respectively, for pool 16. It should be noted that all the flights at 2500' AMT had small gaps in sidelap because of an error in width W in making the flight line template, not discussed until early fall. The flight map shown was one made using the incorrect template, illustrating how a small error in template design can have a critical effect on areal coverage.

Updating and revision of base maps

Whenever a revision or new version of a flight map is required, a new one should be produced rather than remarking over an existing one. It is recommended that the flight dates used be annotated on the file or record copy of each flight map for ease of reference in the imagery interpretative process.

Timing of the aerial photographic mission

Timing is of logistical, operational, and tactical importance. The time of year, week, and day, as well as time available, personnel limitations, and flexibility are discussed.

Time of year

The time of year in which the photography is flown has both tactical and operational significance. River use is essentially seasonal and to some degree, related to the time of year expected to vary with the gross seasonal changes in river stage. Winter use of the river in such activities as snowmobiling and ice fishing, will be difficult at best to detect, due to image resolvability at operational altitudes. Although our camera mount was not yet constructed, a flight was made on March 25th with a borrowed (vertical) mount, as much for training and familiarization of both pilot and photographer as for tactical

reasons. Cloud cover, slight degrees of overexposure (the snow on the ground was highly reflective), and the inability to use two cameras obliquely (to obtain ground control) rendered the imagery, as a whole, unuseable for interpretative purposes. With the spring flood waters comes high river stage. Since the Corps of Engineers reportedly rigidly regulate watercraft use of the river during this period, coordination with the Regulation Division is in order for flights at this time. The first flight made with the two-camera oblique mount was during the Memorial Day weekend, after the cresting and well into the recession of spring runoff waters. Underexposed color infrared film prevented use of that flight's imagery. River use by watercraft is to be expected throughout the course of the summer and into early fall, large and deep-hulled watercraft possibly constrained from shallow areas during late summer, early fall low stage conditions. Early fall sees the opening of duck hunting season, the hunting blind construction beginning in late summer. Aside from the nature of the seasonal use of the river, the extent of useable daylight flying/photography time varies throughout the year, as discussed in the section on time of day.

Time of week

Time of week has only tactical significance. Weekend use of the Upper Mississippi is expected to be heavier than weekday use, at least in regards to watercraft use. A question arises as to whether Mondays and Fridays (aside from the "three-day" holiday weekends) are more representative of weekends or weekday periods. Our flights were not planned to address this particular circumstance. No flights (except for Memorial Day) were made on Mondays or Fridays. Weekday flights were made only on Tuesday, Wednesday, or Thursday. The Fourth of July fell on Wednesday in 1979, allowing a convenient examination of use on both a weekday and holiday.

Time of day

Time of day has logistical, operational and tactical significance. Its tactical significance lies in characterizing river use. Both logistically and operationally, and related to the tactical question, only a fixed length of time is available on a given day with satisfactory sun angle conditions. Too low an angle (early morning and late afternoon/evening) creates both a reddish cast (due to atmospheric refraction) and excessively long shadows, usually a hindrance during imagery interpretation. With the areal scope of the project, the remoteness of our base of operations from the lower pool sites and the relatively low altitude requirement for our 70mm aerial photography, it was not feasible to cover a single pool several times over a single day. Instead we chose to vary, in as much as possible, the time of day coverage throughout the project for given pools. Large format aerial photography can accomplish large areal coverage in a minimum amount of time, but is relatively more expensive. Given a

smaller areal degree of coverage requirement, multiple time-of-day coverage with the smaller 70mm format is quite possible and practical. Table 4-3 indicates the photographic time span for each pool flight made.

Personnel constraints

The flight time available over the course of a day for photography should allow for periodic short rest periods for both pilot and photographer. Aerial flight under these circumstances is fatiguing and crew safety is dependent upon it. Refueling stops (at approximately 3 to 3 1/2 hours flying time) allowed sufficient time for crew rest and any magazine unloading/reloading and camera/intervalometer recharging required.

Flexibility

The aircraft/pilot/photographer availability must be somewhat flexible. Even though specific target dates were determined for our flights, approximately half of those target dates were modified for various reasons, including adverse weather conditions, personnal illness (or discomfort) prior to flight, or unforeseeable aircraft (licensing) inspection delays. Backup dates for each target date should be a planning requirement.

Preparation for the aerial photographic mission

In order to achieve a successful photographic mission, certain preparatory elements must be attended to the day before and/or the morning of the flight. These elements include the photographic system, film and film loading, flight maps and flight log, the aircraft, weather and atmospheric condition compatability, and personnel comfort.

Photographic system

The cameras, lenses, filters, intervalometer and leads, battery chargers, electrician's tape and camera mount should be made available and checked out operationally the day before the flight. The camera body motor drive and intervalometer should also be charged as necessary (a pre-flight charge was routine for this project) the day or evening before the flight. The lens focusing ring should be taped or in some positive way secured at the infinity (∞) position. The focusing ring on the Distagon 40mm lenses used will "creep" away from the infinity position, due to the vibration in-flight unless secured, resulting in out-of-focus imagery. Likewise, the filters should be taped to the rim of the lens (in addition to the mounting characteristic of the filter and lens) to preclude losing a filter in flight. Taping was normally done during system assembly in flight. Both

the lens and filter surfaces should be cleaned with commercially available lens-cleaning tissue the day before (and sometimes) during flight to remove engine oil film residue and/or dust that may have accumulated. Ideally, the surfaces should be cleaned immediately after completion of one day's mission in preparation for the next scheduled mission. If a filter is used (highly recommended), the lens should have no engine oil accumulation, only the filter. There is no set standard for how often to clean a filter of the engine oil film during the course of the mission, but during a refueling stops is a convenient time to do so. Theoretically, there is no need to tape the lens/camera body interface, at least with the Hasselblad system's positive locking device. Caution must be exercised, however, in avoiding accidental pushing of the release button while the belly-hole is open. The button release mechanism in itself does not disengage the lens, but it permits the mount to be turned and thus disengaged, a likely outcome of the aircraft vibration during flight. As a precautionary measure, the lens should be checked by hand when the system is made ready and after any handling of the lens or camera body during flight to insure the locking mechanism is positively engaged.

Film and film loading

Based on the number of pools to be flown and the altitude at which they are to be flown, a sufficient number of rolls of film should be obtained the day before the flight, allowing for at least two extra rolls, and the number of magazines required (or available, as the case may be) loaded using the dark bag shown in photo 4-7. In no event should the magazines be loaded or unloaded outside the dark bag since the film cassettes have been known to experience light leaks, particularly after the first use. It should be noted that each cassette shell is used once as the original (unexposed) film cassette and again (but only once) for exposed film take up. If the film is frozen, at least four hours should elapse (at room temperature) before attempting to load the film. If it is refrigerated, but not frozen, allow two hours. With the Hasselblad magazines, film advance will not occur properly until take-up tension is adequate, requiring several preliminary shutter releases, or exposures. Both prior to and in-flight, attention must be given to this detail.

Flight maps and flight logs

The photographer should insure the availability of his and the pilot's flight maps for the flights to be made and prepare the flight logs the day before the flight. The flight logs should be the same used for record-keeping purposes for ease in post-mission transcription. The recommended format is shown in figure 4-18. This format was not formulated until after all our flights were completed, but it represents the product of the experience gained through the summer and fall flights. 5" x 8" index cards were used, but had a drawback in that the photographer expended greater effort in preparation and annotation. Prior to the flight the

planned number of exposures can be annotated in the "number of exposures in flight line" column. Allow one log form per pool flight (although each roll of film will have its own log form for record keeping purposes).

Aircraft

The pilot should arrange for whatever aircraft prepatory measures are necessary, including annual/periodic inspections between missions, as required. Cabin reconfiguration can and should be accomplished the morning of the flight, since in the case of the Cessna 180 used, the rear passenger seat required removal and the foreward passenger/co-pilot seat to be turned to face aft. If a mission had to be scrubbed, as did happen several times, there is no wasted effort. The time involved to reconfigure the cabin in this way was minimal and was allowed for in our flight schedule.

Weather and atmospheric condition compatability

Both pilot and photographer should check either the local NOAA Weather Service office or flight service/flight information office, or both, for weather and atmospheric conditions. Reliable information is usually available by mid-day or early evening the day before the flight. Our routine involved pilot/photographer coordination both the evening before and the morning of the flight to determine the go/no go status and plan the flight around regional conditions if necessary. Impending severe weather, low overcast conditions and severe haze became go/no go criteria. In some cases, when regional conditions indicated probable compatability for at least some of the pools to be flown, the mission was initiated, and the areas in which predicted compatability was low were again checked in-flight. On occasion, conditions improved and coverage was obtained successfully, emphasizing in part the flexibility necessary in scheduling and planning of flights.

Personnel comfort

It is suggested that motion sickness tablets and what are commonly known as "sick sacks" be made available. The photographer is most likely the person to be in need of both these items, hopefully not both during the same day. Our experience indicated that the photographer, even with no previous experience, quickly adjusted to the spatial disorientation phenomena and on several occasions experienced no motion sickness during six to ten hour missions without having taken motion sickness tablets prior to the mission. However, degree of adjustment depends heavily on the individual. The pilot should seldom, if ever, experience problems since prior adjustment is taken for granted. If illness or discomfort has been experienced within the day or two prior to the flight, consideration should be given to scrubbing the mission if it is to be a long one.

Execution of the aerial photographic mission

Once the mission is initiated, attention must be given to a number of details. These are film magazine unloading/reloading and film labeling, documentation of and exposure compensation for on-site atmospheric conditions, maintaining the flight log, photographer/pilot communication, aircraft to ground communication, supplementary (unplanned) photography, and unforeseen contingencies.

Film magazine unloading/reloading and film labeling

Because of the limited number of 70 exposure magazines available (six in our case) a great deal of in-flight and refueling stop unloading and reloading was required. Once the photographer has "mastered" the dark bag technique, an unloading/reloading cycle will take only six to eight minutes, including identification, per magazine. Through the summer flights, unloading and reloading was accomplished on the ground only, during refueling stops. The photographer was successfully able to use transit time from pool to pool to good advantage by carrying out this process in flight, despite limited cabin space. In flight changes of film should not be attempted, however, until the photographer is well adjusted to aerial flight. It is paramount that film roll identification be accomplished concurrently with the unloading, otherwise there is too great a likelihood of misidentification. The essential elements for the identification label placed on the film cassette are: the roll identifier, consisting of pool number, an alphabetic subidentifier to represent the time sequence of each roll in the pool flight if more than one roll of film was used in each camera, and left or right (L or R) camera orientation (for oblique photography), and also the date flown, flight altitude AMT, film type, lens focal length and filter type. For example, the first two rolls of film exposed over Pool 16 on a given date would be identified as 16-A-L and 16-A-R, the second two rolls as 16-B-L and 16-B-R, and so on. If only one roll of film was used per camera per pool, the roll identifier was simply the pool number and camera orientation, e.g., 16-L and 16-R. The processor's film type label (see figure 5) also reflected the roll identifier, date flown and, of course, film type, so that the exposed film cassette would not have to be exposed to light prior to shipment to the processor.

On-site atmospheric conditions

The cloudiness, haze and turbulence conditions must be observed and recorded on the flight log for each pool, the observation representing a pilot photographer consensus. The discussion of variables CLDVAR, CLDCOD, CLDCOV, HAZE and TURB in the handbook contain the operational definitions used for this project. Further discussion is needed, however, from a methodological perspective. If moderate to severe turbulence is being experienced, a fast shutter speed is needed to preclude image

motion, or blurring. A shutter speed of 1/125th seconds or faster at the 2500' to 5000' altitudes used was felt to be sufficient. Haziness, cloudiness, flight altitude, film type, and solar altitude dictate the exposure setting required. Given that a shutter speed of at least 1/125th of a second is needed, there is some, but not a great deal, of latitude in the shutter aperture, or f-stop, required. The aerial exposure computer referred to earlier should be used to compute the proper exposure. It should be noted that the computation assumes a clear (cloudless) sky. Only an overcast sky should require any real adjustment (opening by one-half to one f-stop generally). The color infrared film (Kodak type 2443) used has a narrower exposure range (or "goof tolerance") than does the normal color (Kodak type 2448), making the use of the aerial exposure computer a necessity. The utility of two early summer flights were lost due to severe underexposure of color infrared imagery. The lack of an exposure computer and photographer inexperience were contributing factors. The solar altitude (time-of-day) becomes a significant limiting factor under overcast conditions. In one particular instance, both clear sky and low overcast conditions were experienced over the areal extent of a single pool, necessitating a choice of the condition for which exposure would be set. The procedure consisted of setting the exposure for the predominant cloud condition based on the (ground observed) areal coverage. To change the exposure setting mid-flight with our operational configuration would have required delaying continuation of the flight more than once. The result of this decision did not significantly impair the quality of the imagery, but it should be noted that the film used was normal color (type 2448). Had color infrared film been used, even with setting the exposure midway, the result would most likely have been negative.

Maintaining the flight log

Including the details referred to in planning and documentation of the on-site atmospheric and exposure conditions, the in-flight annotation of the flight log is a critical element in the overall methodology of the 70mm aerial photography. Supplemented by the flight maps, it becomes the only link between the aerial photography, as executed, and the use of the processed imagery for any reliable interpretative purposes. A running tally of exposures is kept on the flight log for each pair of magazines used (assuming two-camera oblique photography), using the intervalometer frame counter. When changing magazines, it was routine practice in our photography to expose one frame manually with the intervalometer with the photographer's hand across the front of the lenses before resetting the intervalometer frame counter to zero, thereby making the expsoure following the hand image on each roll of film equivalent to exposure number one on the frame counter. The information on the flight log, as annotated, is transcribed onto separate log sheets for each roll of

film, for reasons discussed in MANAGEMENT OF PROCESSED AERIAL PHOTOGRAPHY, but a single form should be used per pool while in flight. A sample form is shown annotated as it would be in-flight in figure 4-19. Of course some elements, such as link number, film roll control number, orientation and river stage information are not recorded on the in-flight log. Upon completing the flight, the photographer should transcribe the in-flight information onto separate forms for each roll of film to await completion when the processed imagery and river stage information are received. Refer to the redundant data variable section in the handbook for operational definitions of the factors shown.

Photographer/pilot communication

Verbal coordination is necessary to execute the aerial photography successfully. The pilot should allow the photographer some lead time in making his approach on each flight line in order for the photographer to adjust for crab, if necessary. Likewise, he should forewarn the photographer of the approaching first exposure station for each flight line, since the photographer has limited forward vision. The photographer oftentimes must use landmarks, tips of islands, etc. that are laterally equivalent to the first and last exposure stations, along with the pilot's forewarning, to execute the photography properly. Conversely, the photographer should appraise the pilot when the last exposure station has been reached, so that the pilot does not prematurely leave the flight line, and whether or not the aircraft's relative ground speed is adequate. Too fast and gaps in forward coverage will occur, too slow and the risk of exceeding the exposure capacity of the film cassette is run. Needless to say, any problems arising during the course of the photography, such as camera malfunction or photographer/pilot misjudgement, should be immediately communicated.

Supplementary (unplanned) photography

From mid-summer on, incidental low level photography was flown to supplement the higher level photography, acting in the line of multi-stage sensing. It was flown after completion of the planned photography, and usually at altitudes between 300' and 800' AMT. Appropriate annotations were made on the flight log as to location of the low level flyover site(s), the time and number of exposures involved. The low level supplemental imagery was not digitizeable in the interpretative process due to lack of a reasonable degree of ground control with the extremely small areal coverage per frame. This is to say that it was not used in the same geo-reference sense for which the planned photography was designed. Adjustments in exposure setting and time intervals are necessary for the supplementary photography. Use of the exposure computer for the change needed, if any, due to change in flight altitude, and a direct altitude proportional adjustment in the exposure time interval are all that is required in the way of adjustments.

Contingencies

Occasionally, unforeseen problems arise. Those experienced are discussed here. Camera malfunction in-flight occurred twice in the early summer flights. The flight lines were flown with one camera (see variables ORIENT and REVERS in handbook). A much simpler and practical recommended solution in the long term is to have a third (backup) camera and lens available on each flight. Any and all disruptions in photographic coverage as planned must be documented on the flight log. On several occasions, excessive ground time was experienced waiting for weather or atmospheric condition improvement. Since the conditions may be related to river use, they should be documented on the flight log.

Film processing

Once the aerial photographic mission is completed, the exposed film should be promptly sent to the processor. Discussed are the elements of pre-processing film handling, the processing request, packaging for shipment, and the shipment to and from the processor.

If the film cassettes and cassette containers have been appropriately and properly labeled while in flight (see Execution of the aerial photographic mission) the film will require no further handling except for packing into the shipping container. Under no circumstances should the film cassettes be exposed to light before processing. The processing request should be made in duplicate, one for records, the other for shipment with the exposed film. Do not rely only on the film type label to get the job done. The investment in time and money is well worth a specific processing request. A sample request is shown in figure 4-20. A sturdy corrugated cardboard box of sufficient size for the shipment, some non-flammable lightweight packing material (such as foam peanuts), strapping tape and the three labels shown in figures 4-3, 4-4 and 4-5. One film type label must be used for each roll of film. One shipping/mailing label and as many "do not expose" labels as desired are affixed to the exterior of the shipping container. Our film shipments were made via UPS insured for at least the cost of the film. UPS proved to be an efficient, cost-effective courier. No excessive delays were experienced from either the processing lab or UPS. The custom lab will most likely return the shipment adequately insured, but it is advisable to request an insured return shipment anyway.

MANAGEMENT OF PROCESSED AERIAL PHOTOGRAPHY

The management of any large scale, long term aerial photographic project will require an efficient imagery accession, storage and retrieval system and a procedure for imagery screening and preparation for interpretative processing.

Imagery accession system

Both a numerical and a descriptive index to the imagery are required. The numerical index should be sufficient to uniquely identify each roll of processed film. The roll identification assigned to each roll of exposed film during flight is unique only for the date flown and should not be used as the permanent numerical index, but can be used (as it was in our project) along with the date flown as the descriptive index. The permanent numerical index in our case was the five-digit processor-assigned control number (see variables FLMLOT and FLMSEQ in the handbook). Although these numbers were unique for the course of our project, it is not the recommended method, since it had no temporal significance and no measure of in-house control of number assignment. The recommended system, using the same field width assignment (refer again to FLMLOT and FLMSEQ in the handbook) is to use the current year (e.g., 79 for 1979, 80 for 1980, etc.) and a sequentially assigned three-digit number, from 001 to 999, within each year for the FLMLOT and FLMSEQ values, respectively. This method guarantees a unique numerical index with in-house control for each roll of processed film. However, the requirements of the interpretative processing method, as developed, require that each flight line be uniquely identifiable across all imagery. It was felt that a single identifier should accomplish this purpose, hence the use of the link number concept (see variable LINK in the handbook). The link number is also sequentially-assigned. For the scope of our project a three-digit number was sufficient. For large scale, long term projects the field width for the link number should be expanded to four or even five digits. The film roll numerical index and link numbers should be assigned during the pre-interpretative screening of the processed imagery. The film roll numerical index or descriptive index should be the physical accession device, while access to the encoded redundant data for each flight line is served by use of the film roll numerical index (FLMLOT and FLMSEQ), flight line number (FLINE) and link number (LINK) together to insure positive data access.

Imagery storage and retri

The proper storage of processed imagery requires only that the storage area not undergo extreme temperature or humidity variations. A computer card rollout-drawer filing cabinet is ideal for storing the processed imagery. Division by pool and date flown (descriptive index) by film roll numerical index is recommended, whichever best serves the needs of the user. Since our film roll index numbers had no temporal significance, storage and retrieval was geared to the descriptive index.

Imagery screening

As soon as possible after receiving the processed imagery (and river stage information) the partially completed aerial photographic log forms, transcribed from the original flight log should be completed with the required roll index numbers, camera orientation, link numbers and river stage information. The completed forms for one particular flight are shown in figures 4-21 a, b, c, and d. The original flight log (had the form been used for in-flight annotation as now recommended) is shown in figure 4-19.

Conformance with flight log

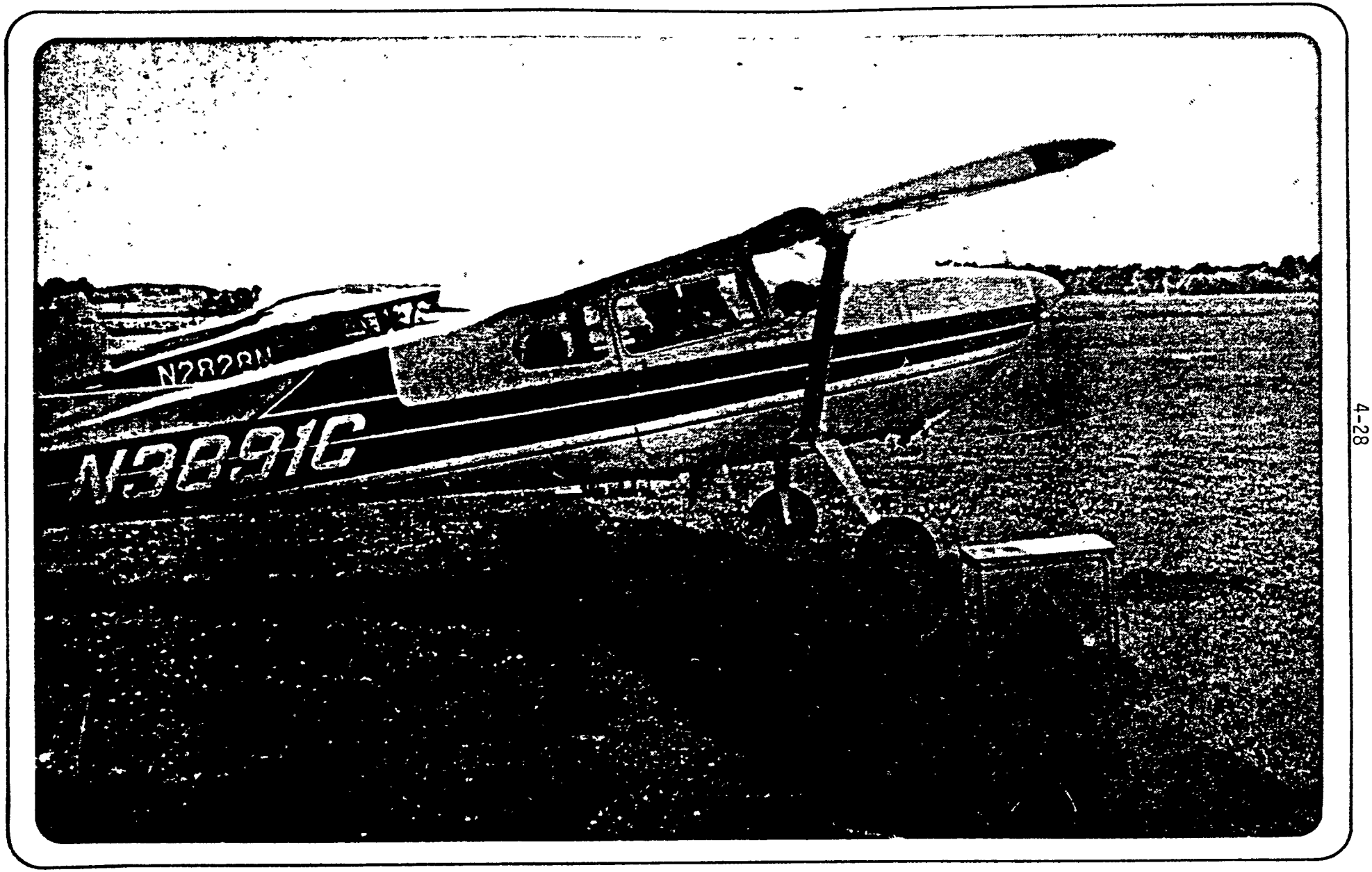
The imagery should be screened to insure that the number of exposures in each flight line on the imagery matches the number recorded from the intervalometer frame counter in flight. If there is any discrepancy the imagery should be checked to insure there are no gaps in forward areal coverage, or endlap. During one of the early summer flights, one camera's motor drive battery began to fail and exposed only one frame for each two the companion camera exposed. The conformance procedure will detect this situation. On the other hand, the photographer may merely have misrecorded the intervalometer frame count in flight or transcribed it incorrectly from the flight log. In either case, the discrepancy must be accounted for and corrected, if possible, before encoding of redundant data takes place during the imagery interpretative process.

Frame number annotation

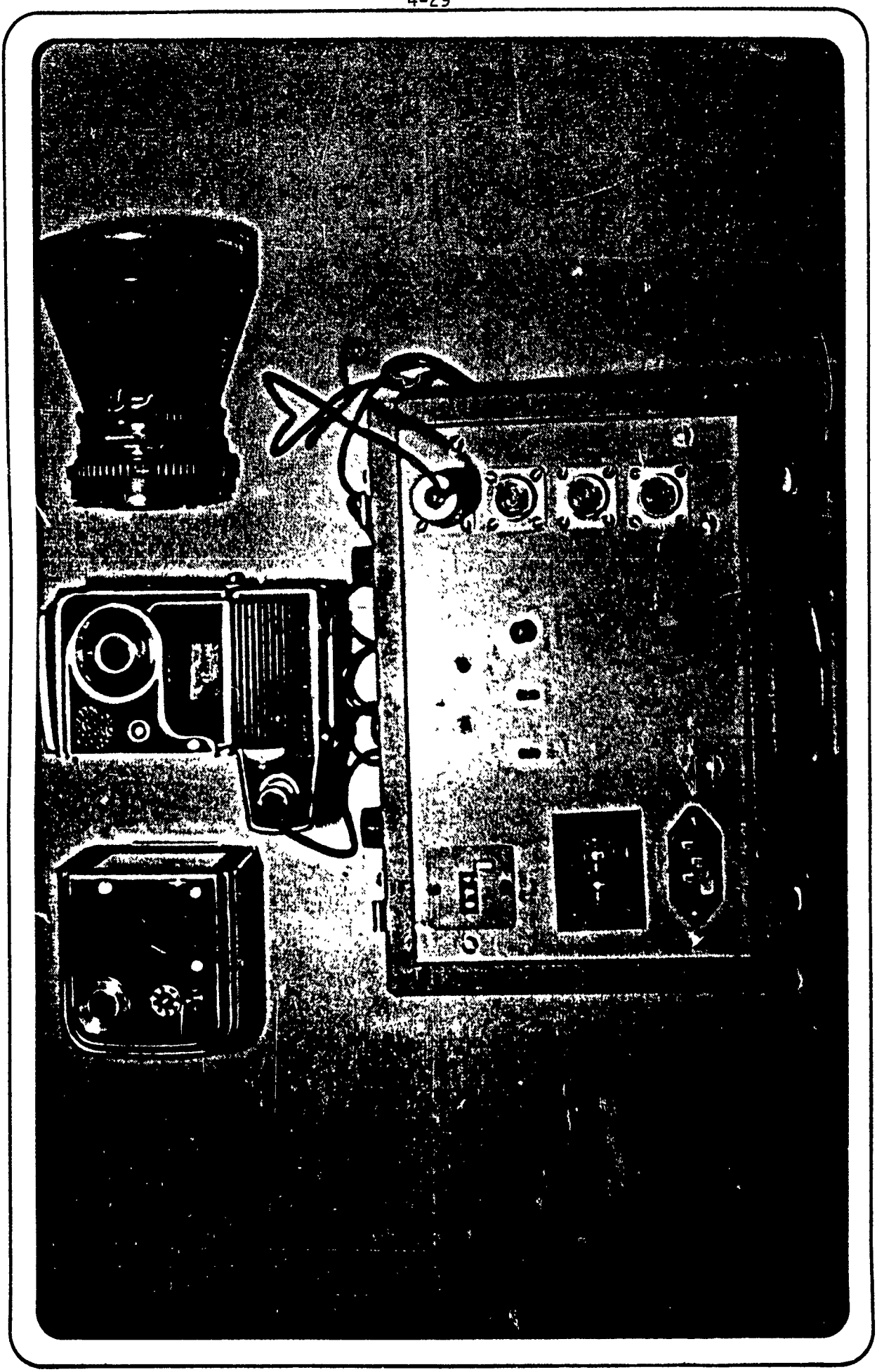
During the imagery interpretative process, the frame number (see variable ROLSEQ in the handbook) is an integral part of the data entry and the interpreter must not have to roll the film back and forth to merely determine the flight line and frame number at which he has decided to target. Hence the need for numbering the frames at specific intervals. Numbering the first and every fifth frame thereafter, plus marking the initial frame of each flight line, with small signal dots in the frame margins adequately meets this requirement.

Imagery utility

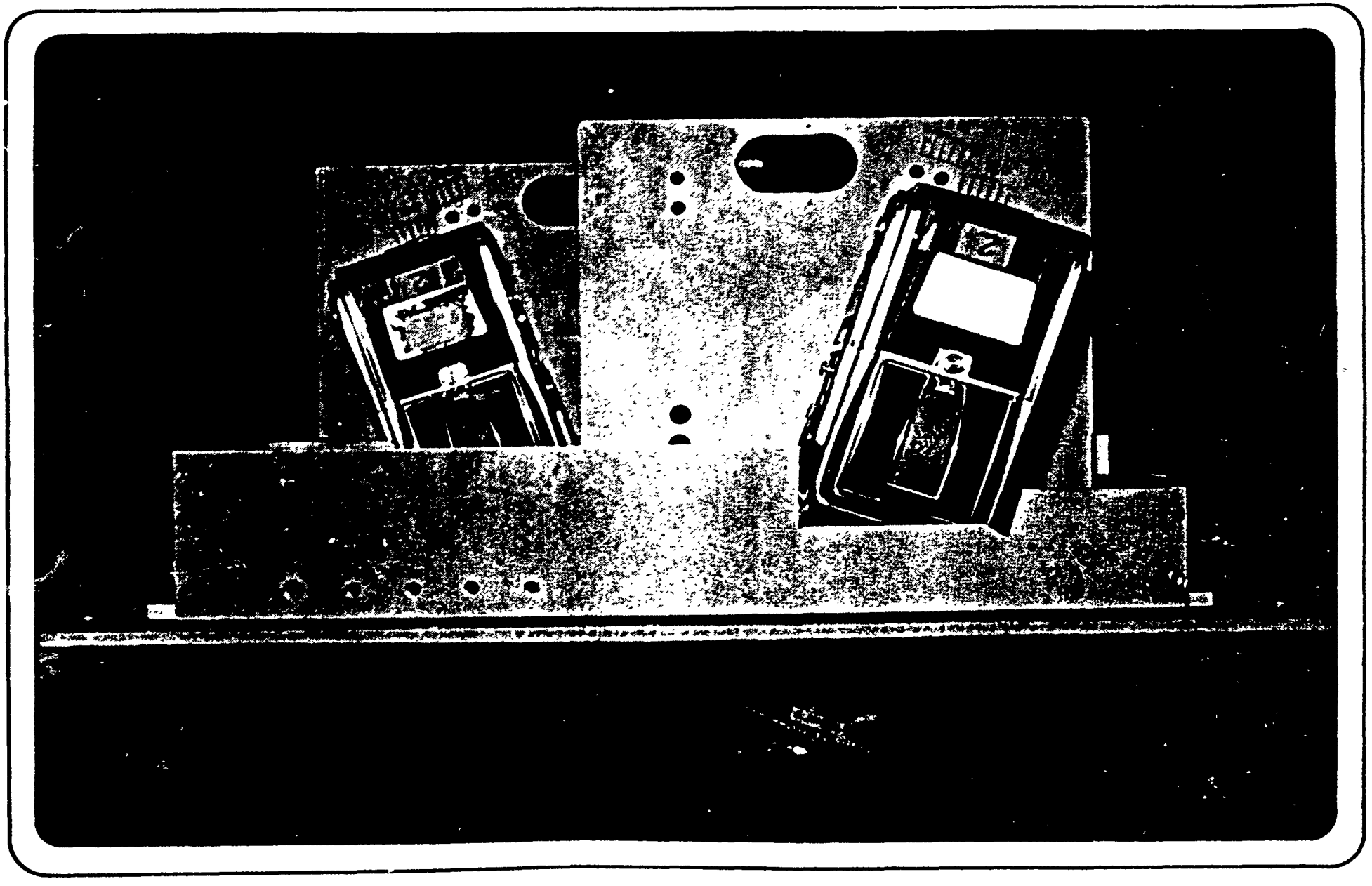
The screening process allows the utility of the imagery to be determined. Underexposed or overexposed imagery may not be useable. Likewise, camera shutter malfunctions or dissynchronization can render the imagery unuseable. Excentions of this kind should be noted in the remarks area of the flight log(s) concerned.



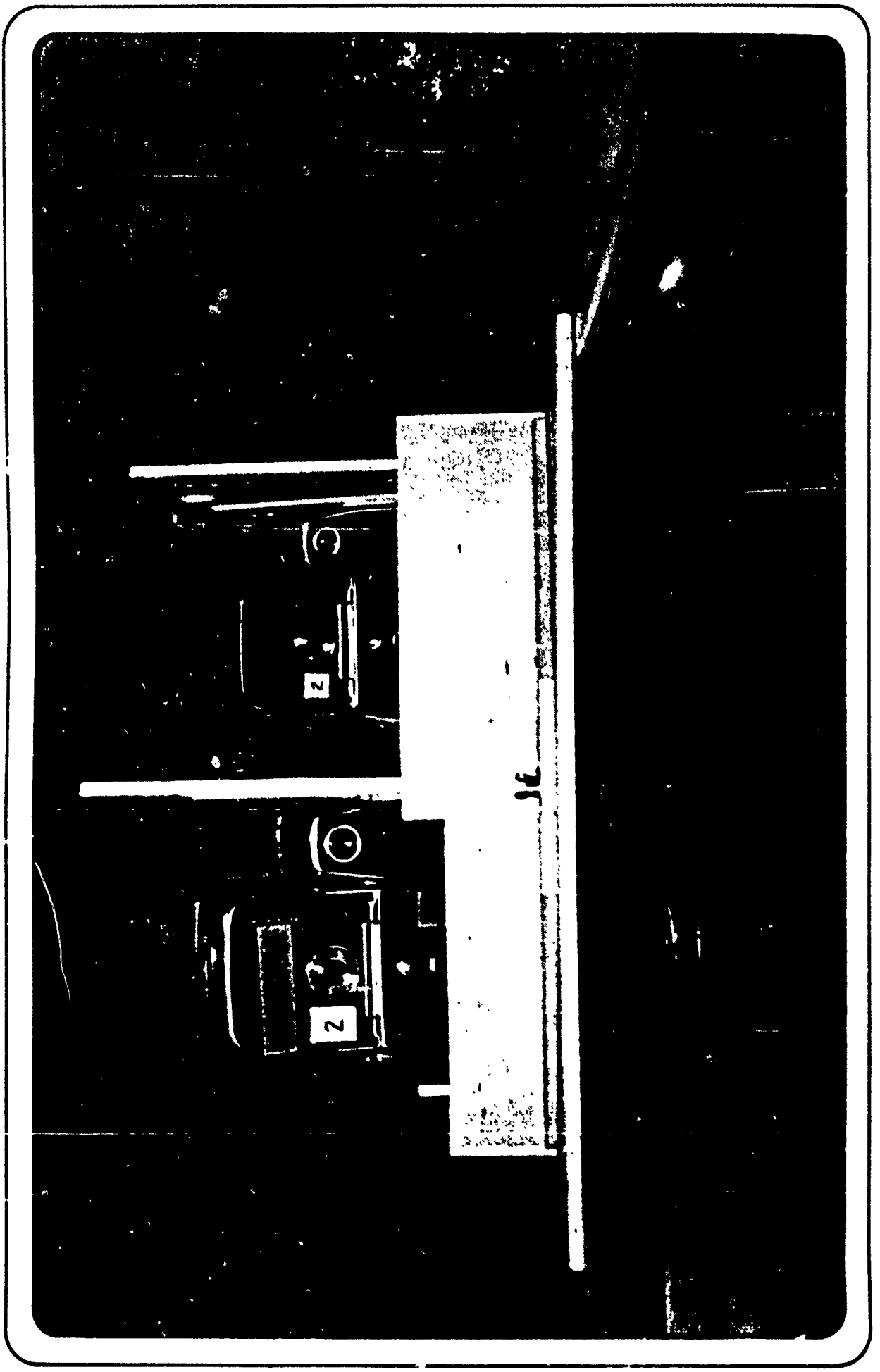
Photograph 4-1 Cessna 180



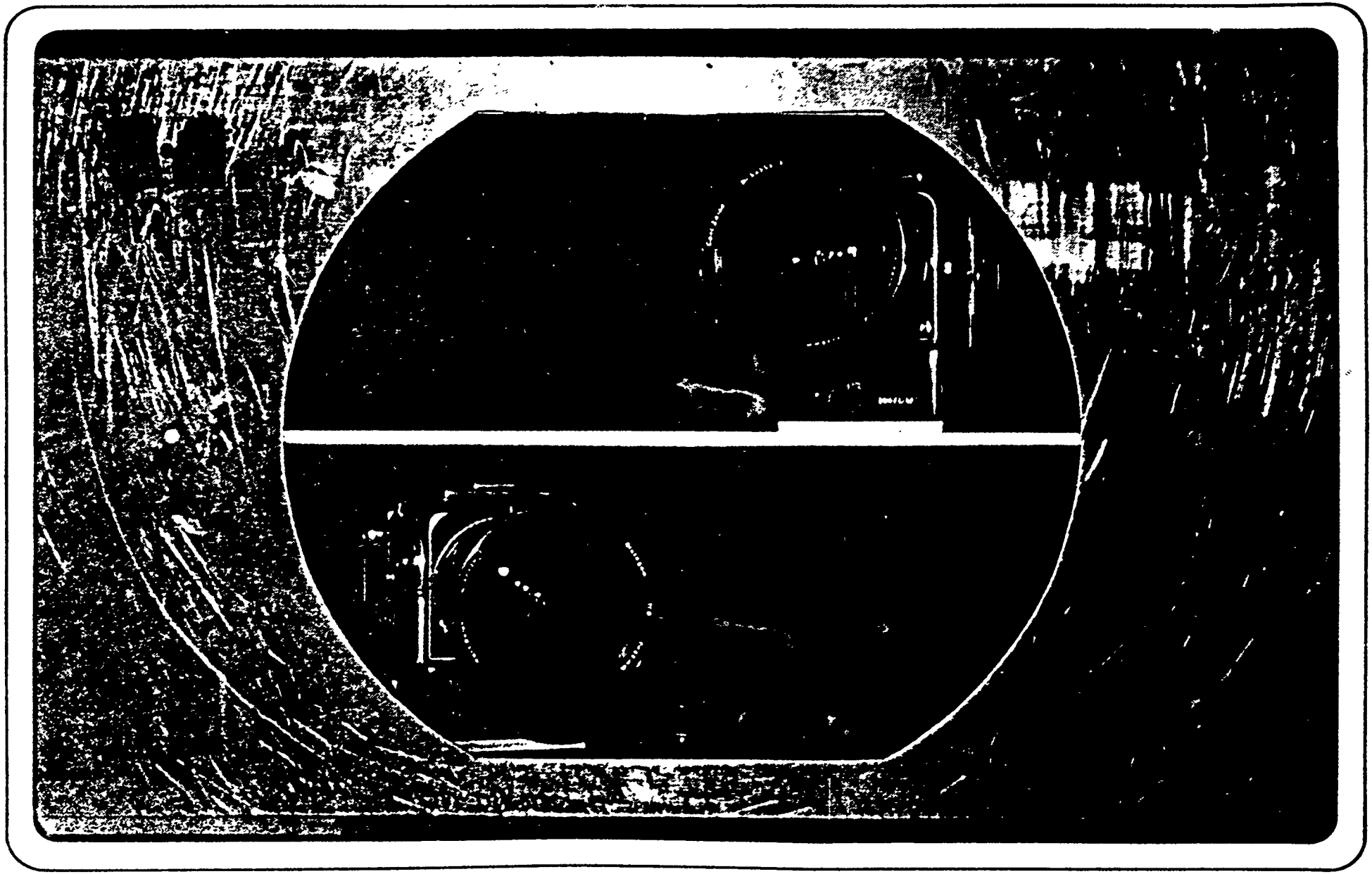
Photograph 4-2 70mm Photographic System



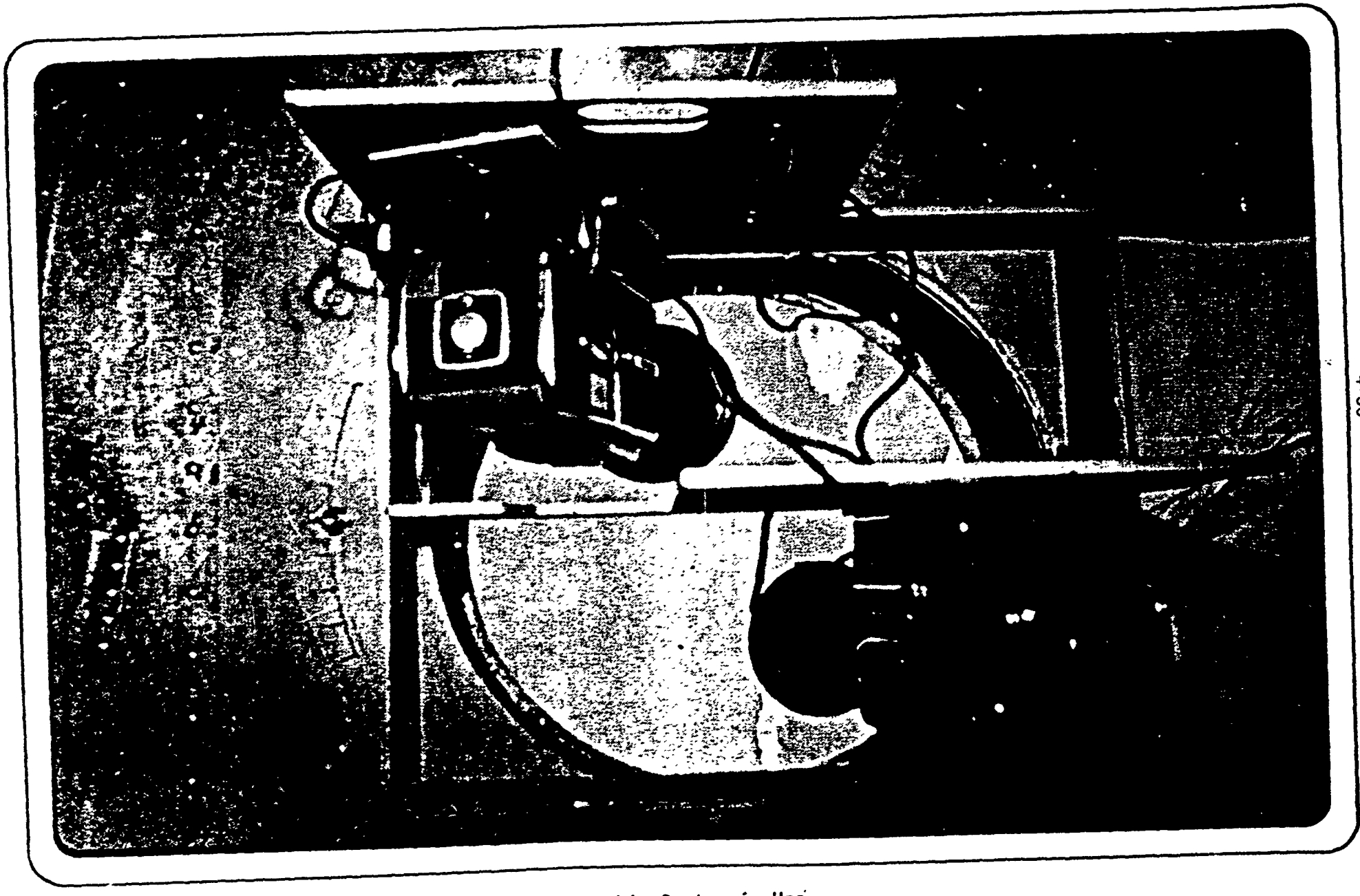
Photograph 4-3 Camera Mount (front view)



Photograph 4-4 Camera Mount (side view)



Photograph 4-5 Camera Mount (bottom view)



Photograph 4-6 Camera Mount and Photographic System in Use



Photograph 4-7 Dark Bag

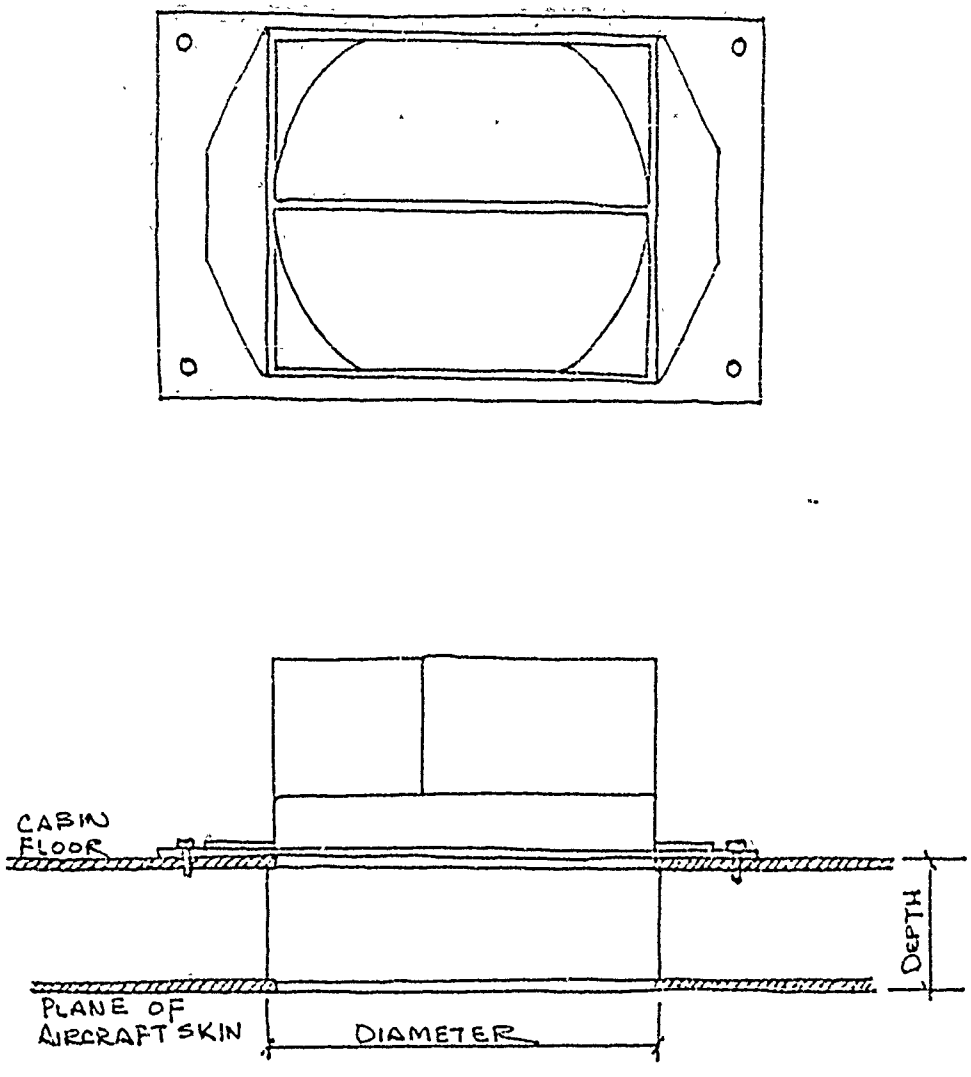


Figure 4-1 Belly-hole

Figure 4-2 Camera Mount Design

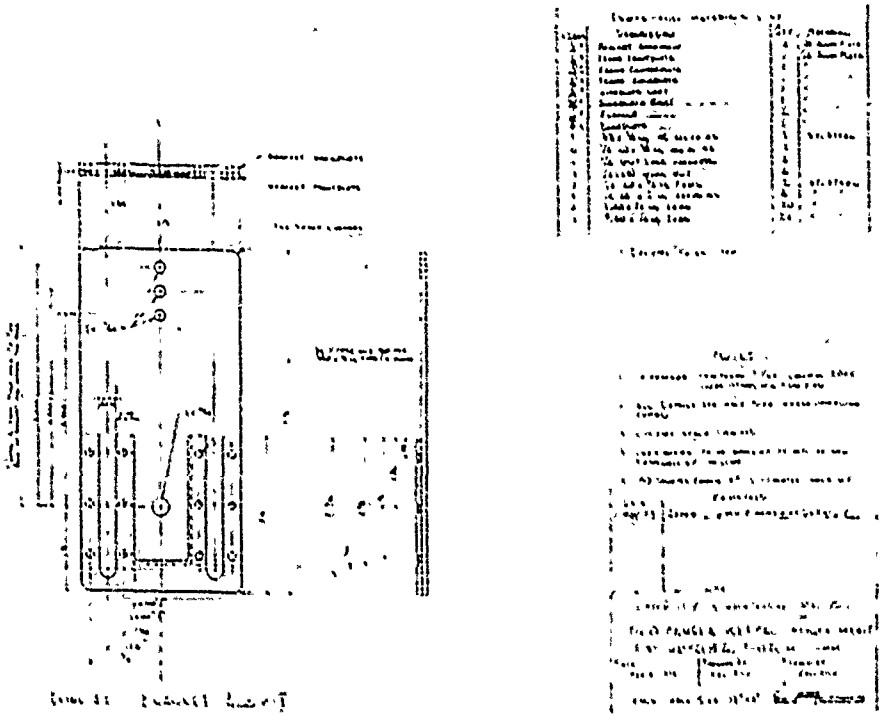


Figure 4-2a Bracket Assembly

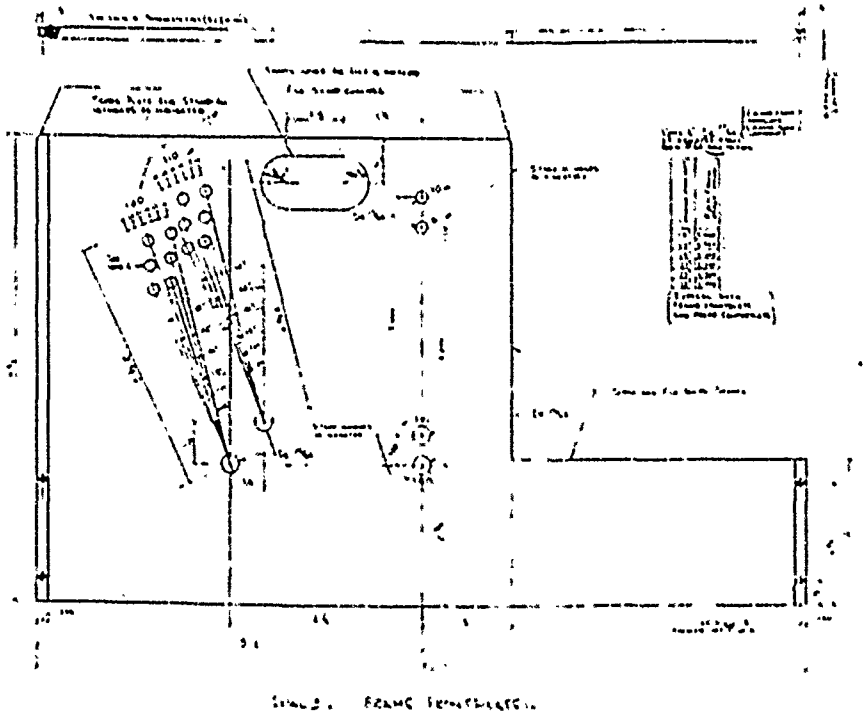


Figure 4-2b Frame Frontplate

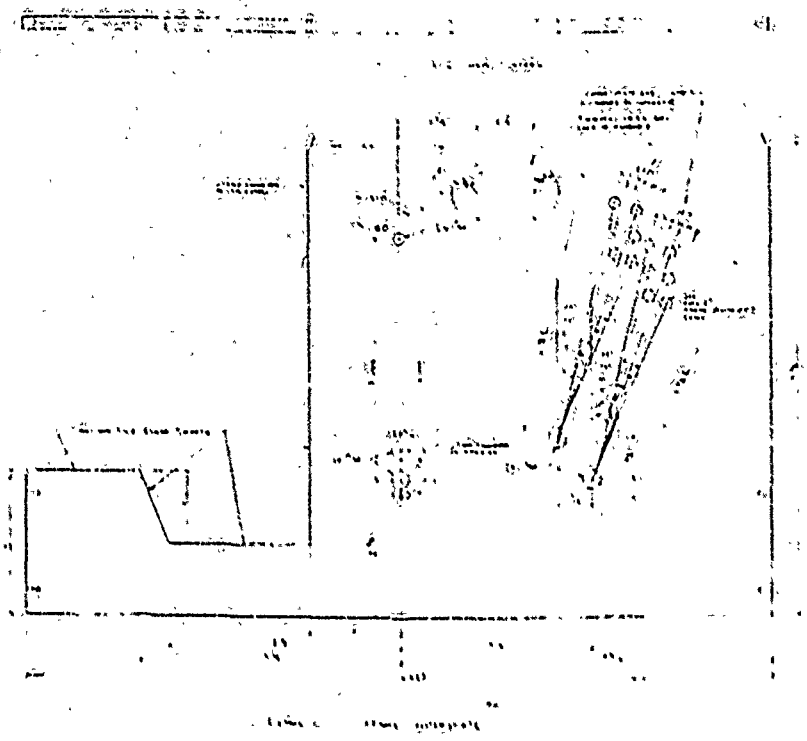


Figure 4-2c Frame Centerplate

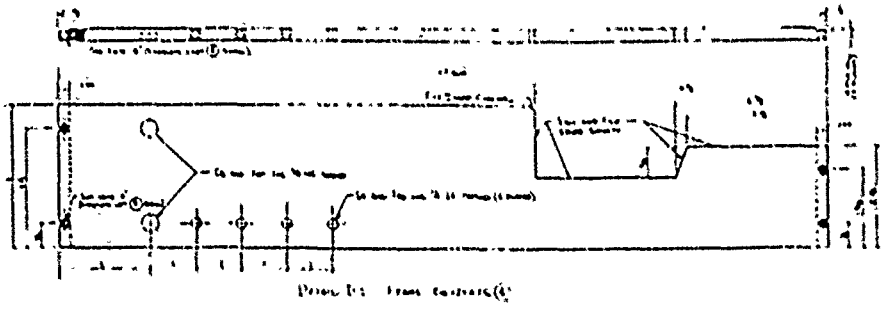


Figure 4-2d Frame Backplate

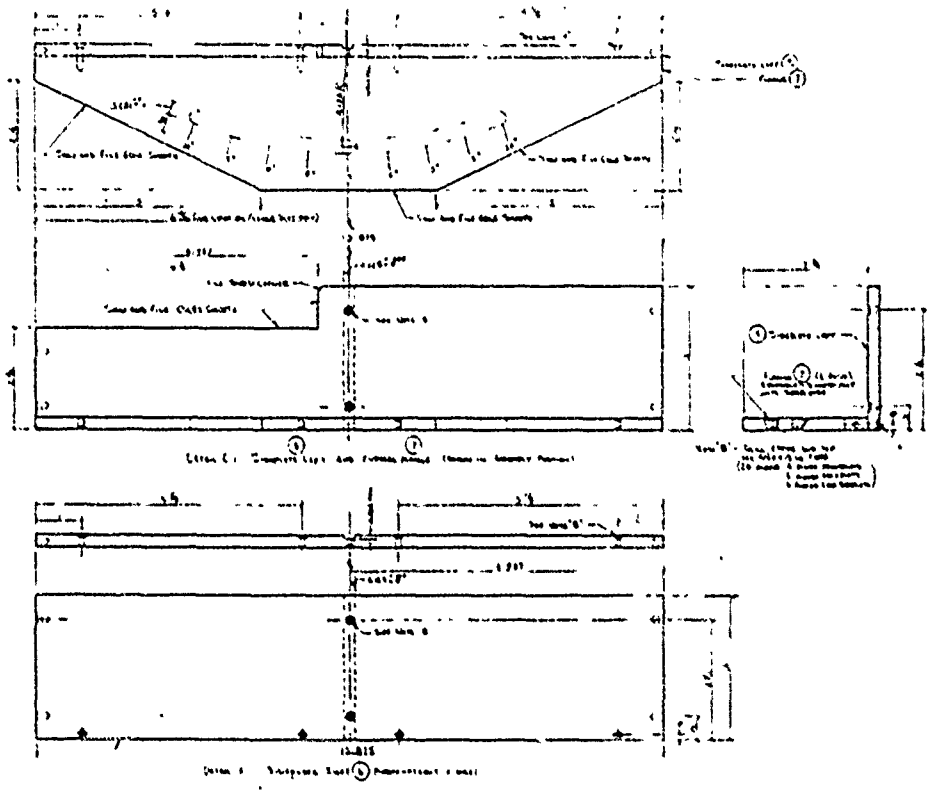


Figure 4-2e Frame Sideplates and Flanges

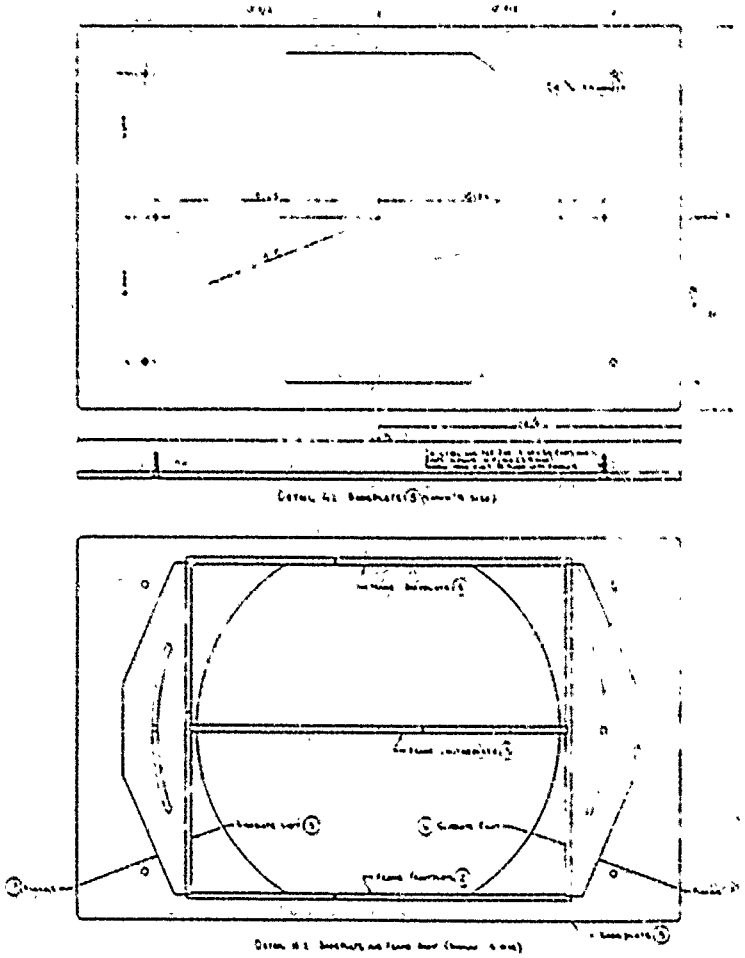


Figure 4-2f Baseplate and Mount Assembly

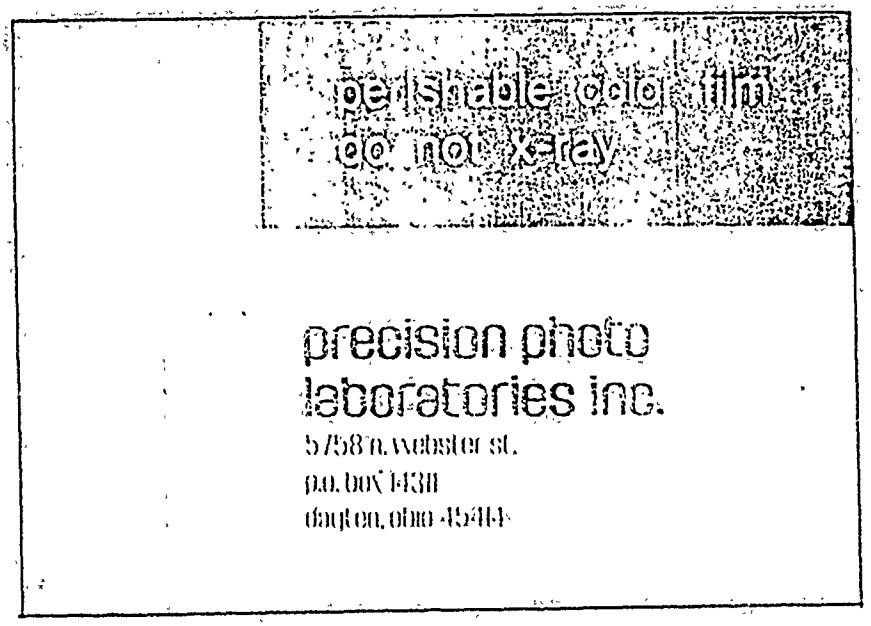


Figure 4-3
Film processing
shipping
label

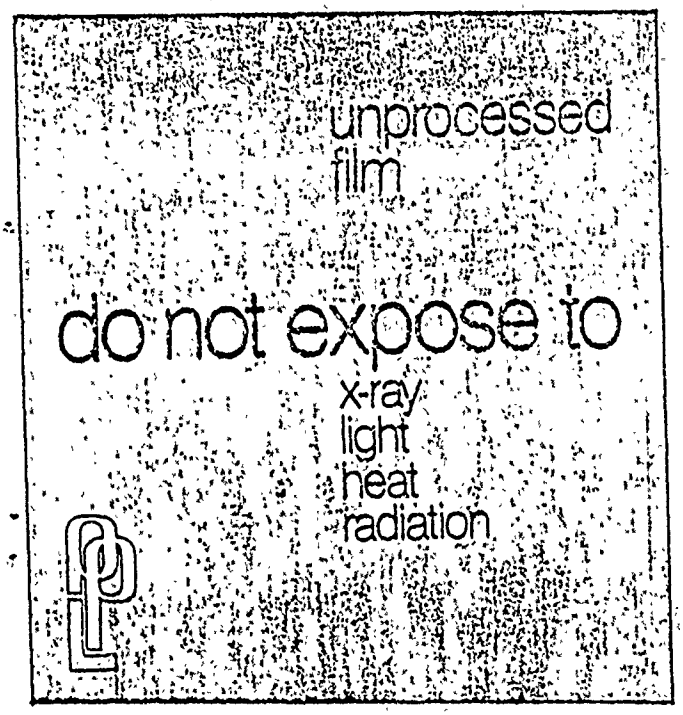


Figure 4-4
"Do Not Expose"
Label

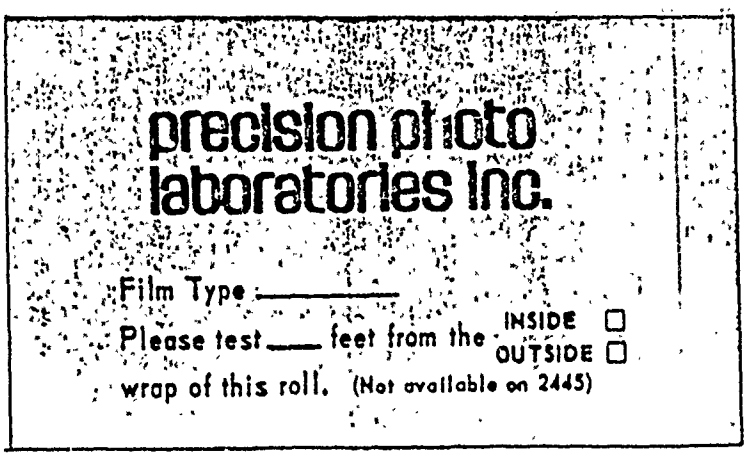


Figure 4-5
Film Type
Label

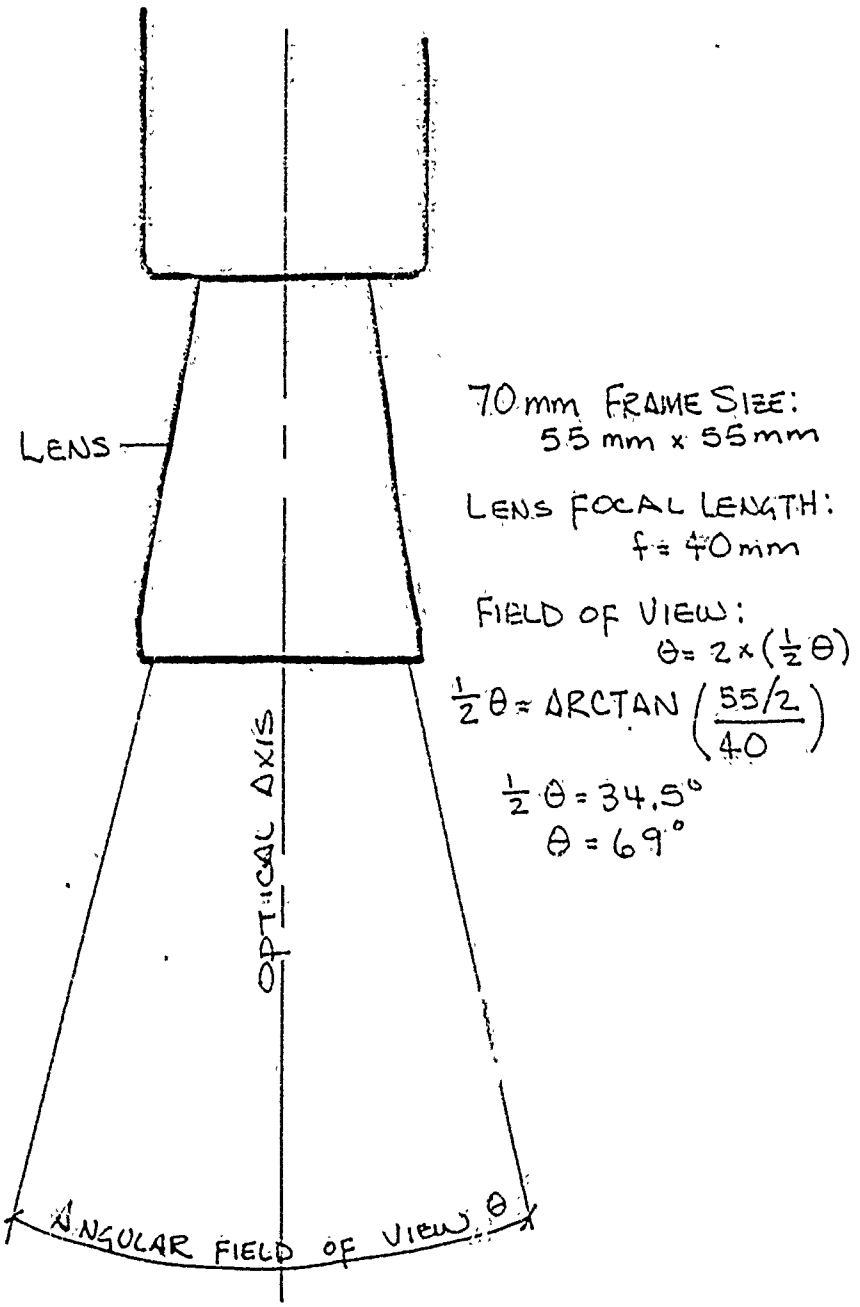


Figure 4-6 Field of View

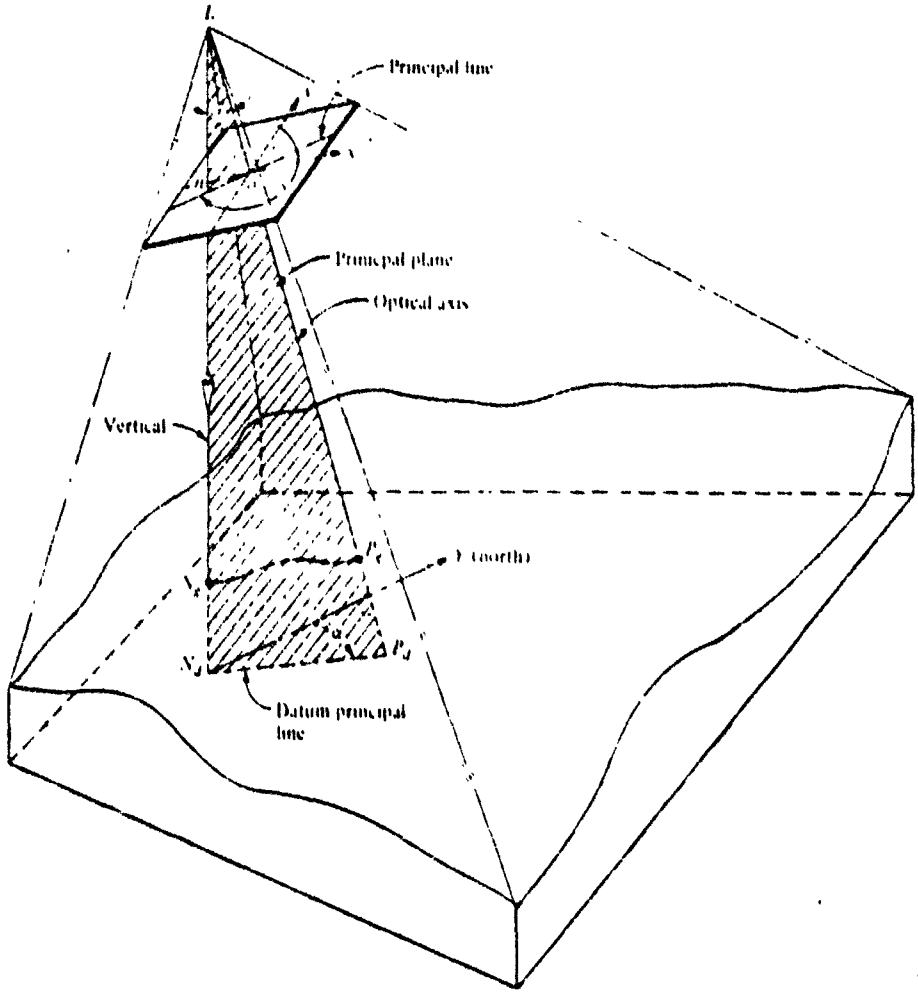


FIGURE 13-1
Geometry of a tilted photograph showing tilt-swing-azimuth angular orientation.

and (2) a translation of origin from o to n. The rotation angle θ is defined as

$$\theta = s - 180^\circ \qquad (13\text{-}1)$$

The coordinates of image point a after rotation are x'_a and y''_a, as shown on Fig. 13-2*a*. These are calculated using the following rotation equations

$$x'_a = x_a \cos\theta - y_a \sin\theta$$
$$y''_a = x_a \sin\theta + y_a \cos\theta$$

Figure 4-7 Geometry of Titled Photographs

From Elements of Photogrammetry, Paul R. Wolf, McGraw-Hill, 1974.

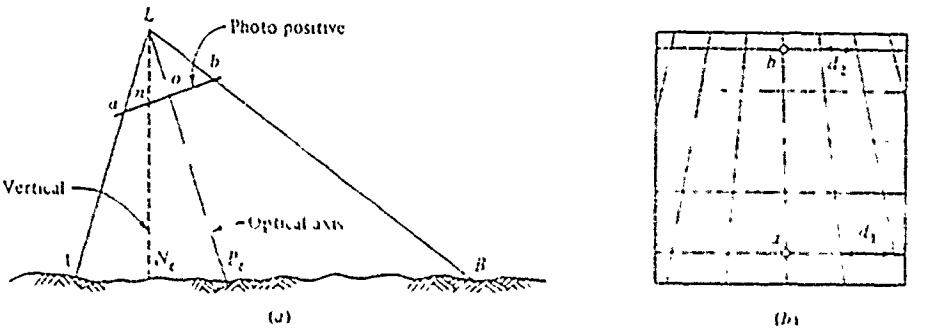


FIGURE 13-3
(*a*) Principal plane of a tilted photo taken over flat ground. (*b*) Image on the tilted photo of a square ground grid.

also cause changes in scale, but scale in various parts of the photo is further affected by the magnitude and angular orientation of the tilt. Figure 13-3*a* illustrates the principal plane of a tilted photograph taken over a square grid on flat ground. Figure 13-3*b* illustrates the appearance of the grid on the resulting tilted photograph. Due to tilt, object distance LA in Fig. 13-3*a* is less than object distance LB and hence a grid line near A would appear larger (at a bigger scale) than a grid line near B. This is illustrated on Fig. 13-3*b* where photo distance d_1 appears longer than photo distance d_2, yet both are the same length on the ground.

The scale at any point on a tilted photograph is readily calculated if tilt and swing for the photograph and the elevation of the point are known. Figure 13-4 illustrates a tilted photo taken from a flying height H above datum. Lo is the camera focal length. The image of object point A appears at a on the tilted photo, and its photocoordinates in the auxiliary tilted photocoordinate system are x'_a and y'_a. The elevation of object point A above datum is h_A. Object plane $A1'K_A1''$ is a horizontal plane constructed a distance h_1 above datum. Image plane $a'kk'$ is also constructed horizontally. The scale relationship between the two parallel planes is the scale of the tilted photograph at point a because the image plane contains image point a and the object plane contains object point A. The scale relationship may be derived from similar triangles Lka' and LKA' as follows:

$$S_a = \frac{Lk}{LK} = \frac{ka'}{KA'} \qquad (a)$$

but

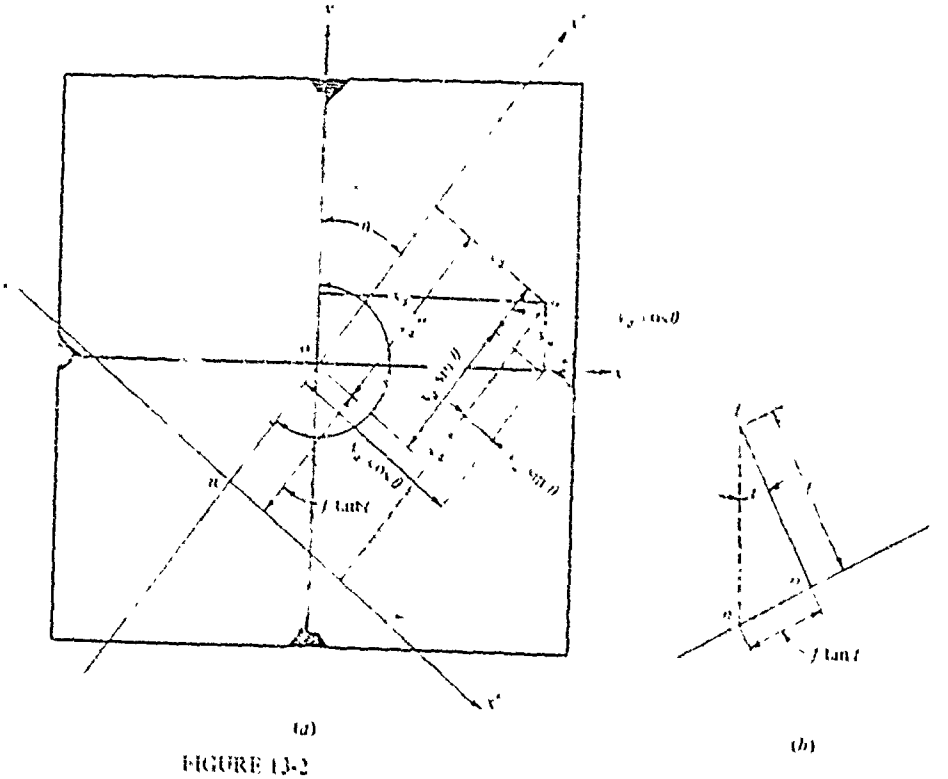
$$Lk = Ln - kn = f/\cos t - y'_a \sin t$$

also

$$LK = H - h_A$$

Figure 4-8 Tilted Photograph with Square Ground Grid

From Elements of Photogrammetry, Paul R. Wolf, McGraw-Hill, 1974.



(a) (b)

FIGURE 13-2
(a) Auxiliary $x'y'$ image coordinate system for a tilted photo. (b) Principal plane of a tilted photo.

The components of the above two rotation equations are illustrated in Fig. 13-2*a*. Auxiliary coordinate y'_a is obtained by adding the *translation distance* om to y''_a. From Fig. 13-2*b*, which is a view of the principal plane, om is $f \tan t$. Therefore the coordinates of a point in the required auxiliary coordinate system are

$$\begin{aligned} x'_a &= x_a \cos\theta - y_a \sin\theta \\ y'_a &= x_a \sin\theta + y_a \cos\theta + f \tan t \end{aligned} \tag{13-2}$$

13-4 SCALE OF A TILTED PHOTOGRAPH

In Chap. 6 it was shown that scale variations in a vertical photograph are the result of variations in object distance (distance from camera to ground). The shorter the object distance, the larger the scale and vice versa. For vertical photos, variations in object distances were caused only by topographic relief. In a tilted photograph, relief variations

Figure 4-9 Tilted Photograph Auxillary Coordinate System
From Elements of Photogrammetry, Paul R. Wolf, McGraw-Hill, 1974.

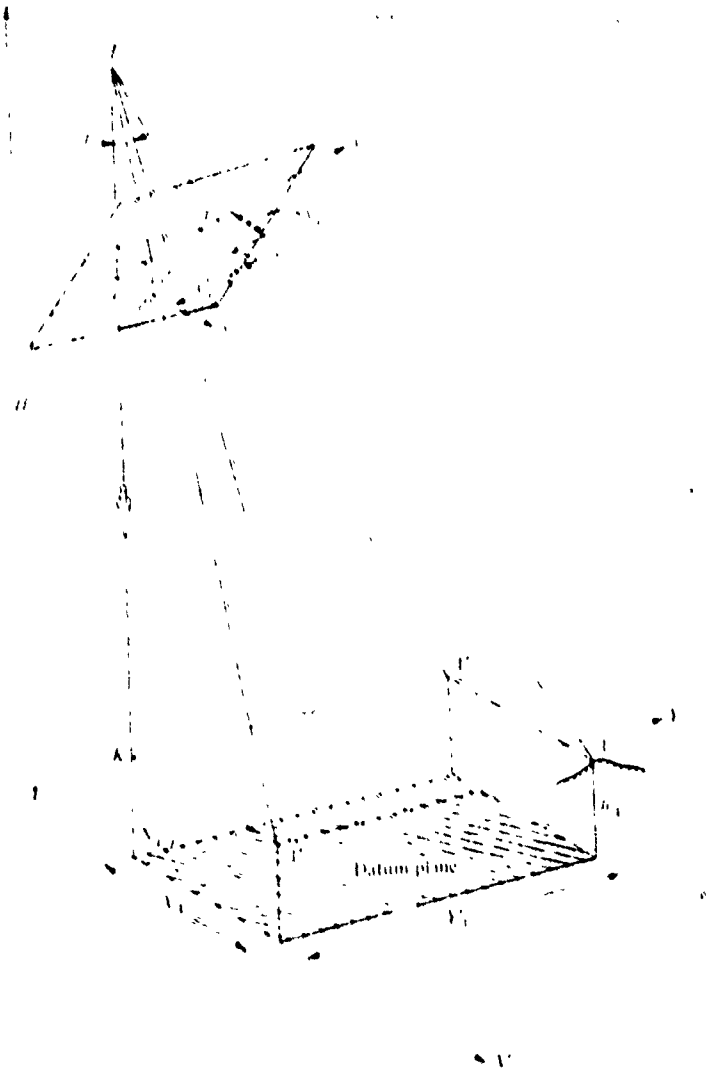


FIGURE 13-4
Scale of a tilted photo, and ground coordinate system.

Substituting $l.K$ and $l.K$ into (a) and dropping subscripts

$$S = \frac{f/\cos t - y'_a \sin t}{H - h} \qquad (13\text{-}3)$$

In Eq. (13-3), S is the scale on a tilted photograph for any point whose elevation is

Figure 4-10 Scale of Tilted Photograph with Ground Coordinate System

From Elements of Photogrammetry, Paul R. Wolf, McGraw-Hill, 1974.

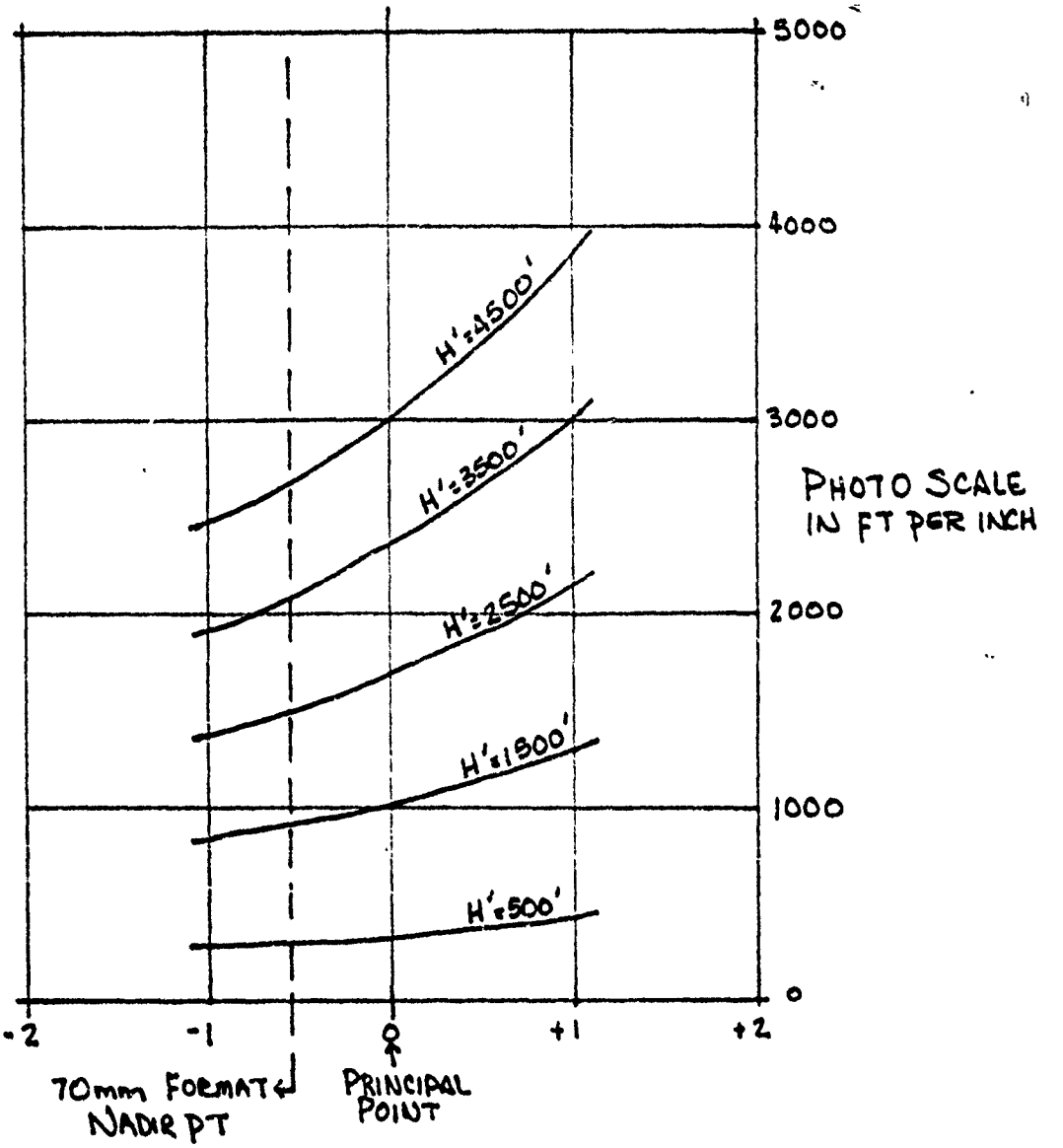


Figure 4-11 Change in Scale in Tilted Photographs

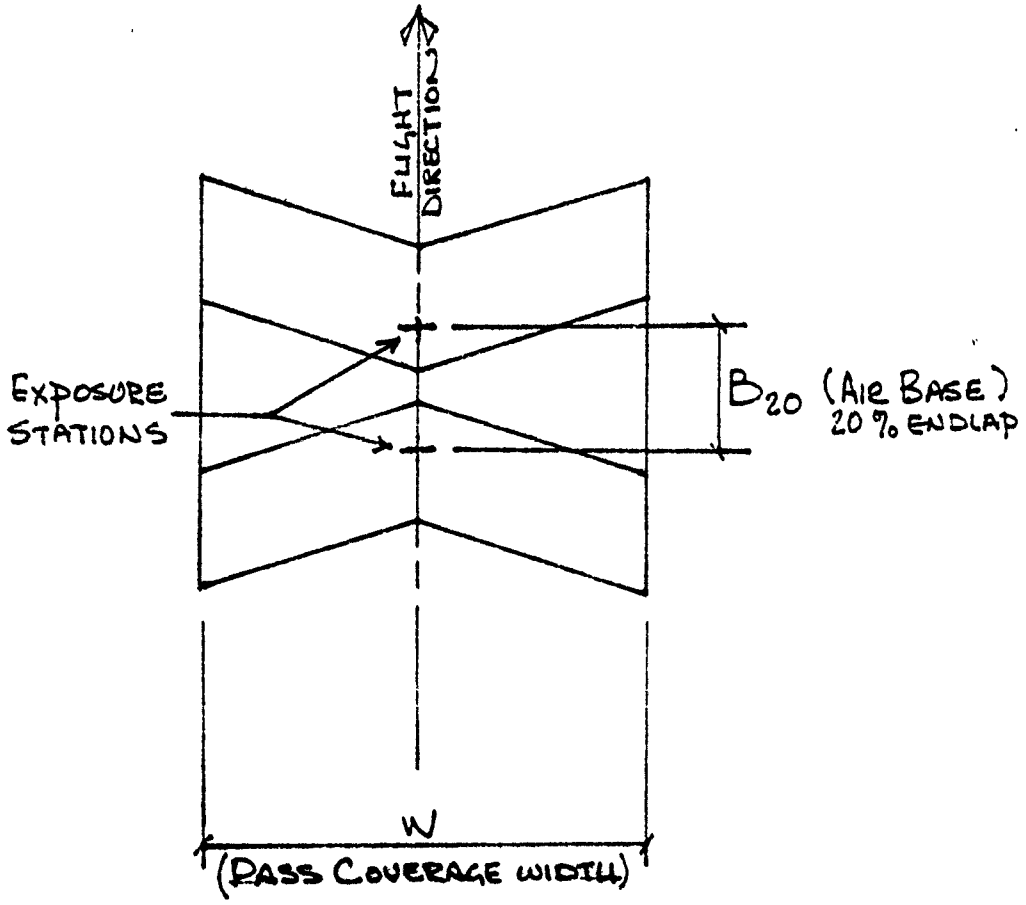


Figure 4-12 Two-Camera Low Oblique Flight Line Template Elements

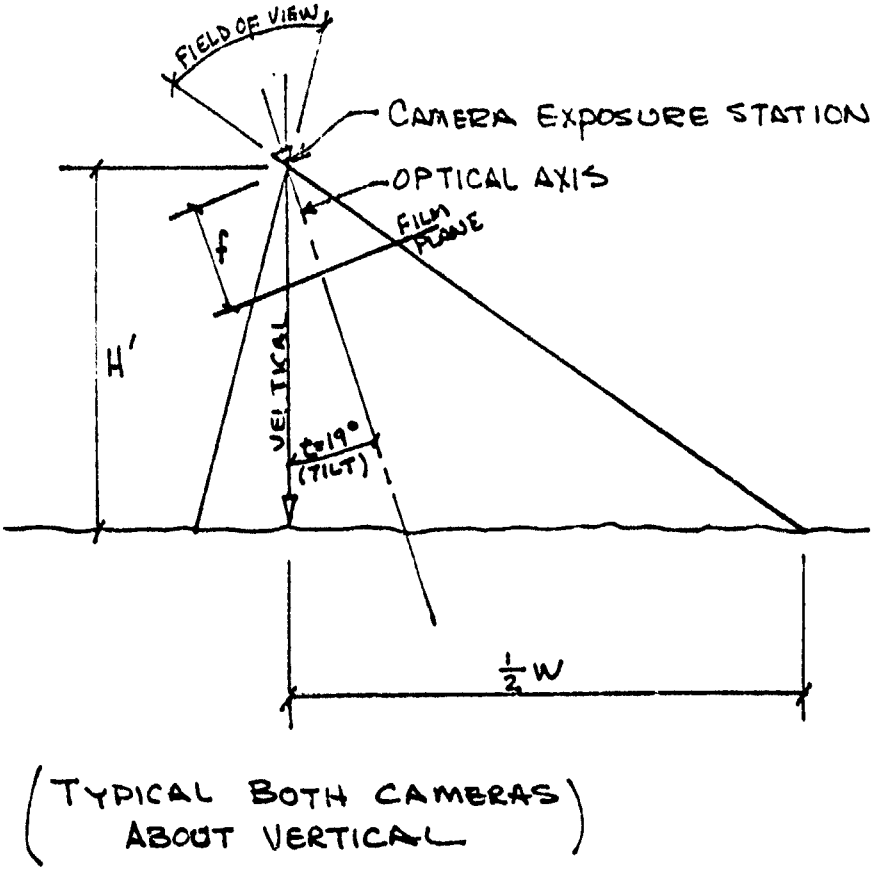


Figure 4-13 Cross Sectional View of Oblique Pass Coverage

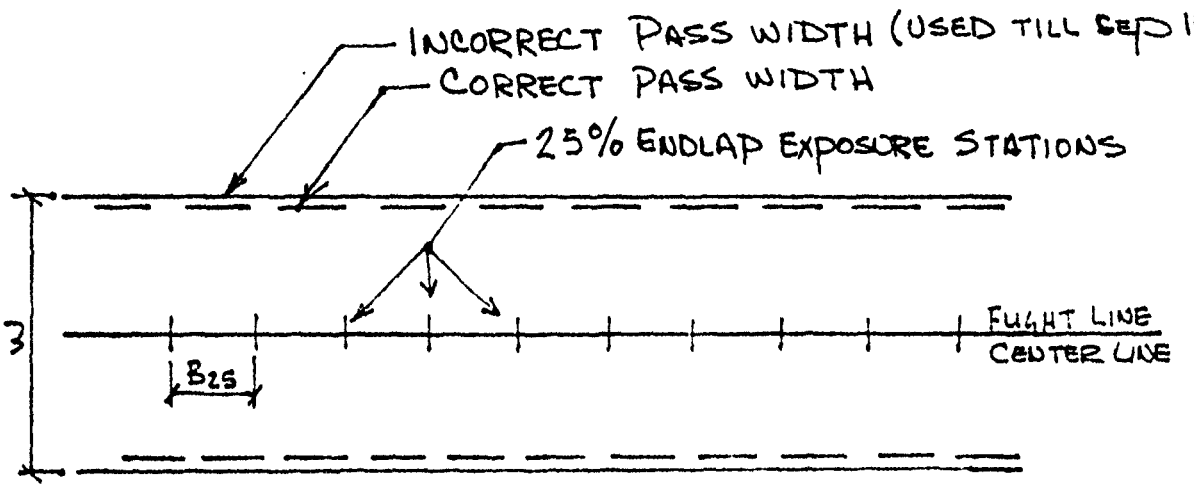


Figure 4-14 Flight Line Template
H' = 2500' AMT

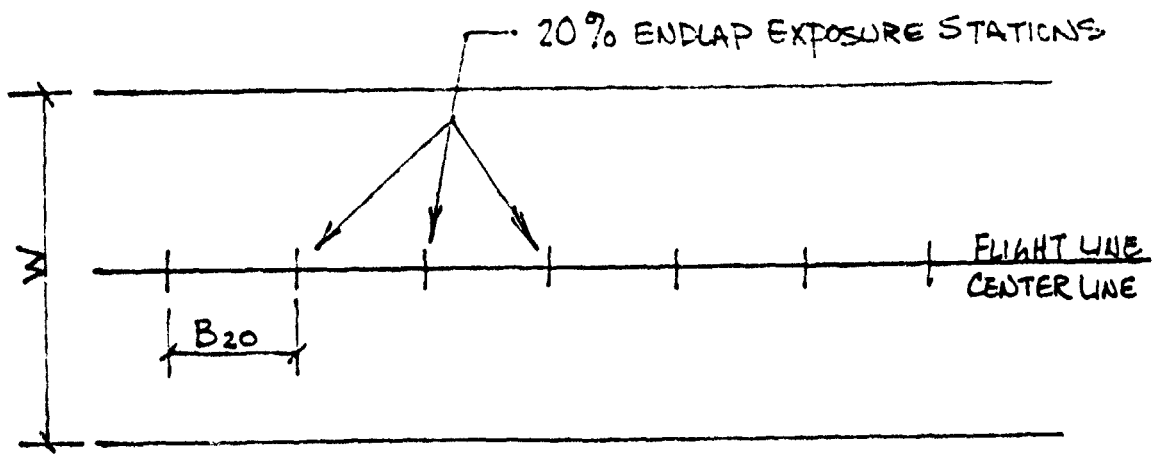


Figure 4-15 Flight Line Template
H' = 3500' AMT

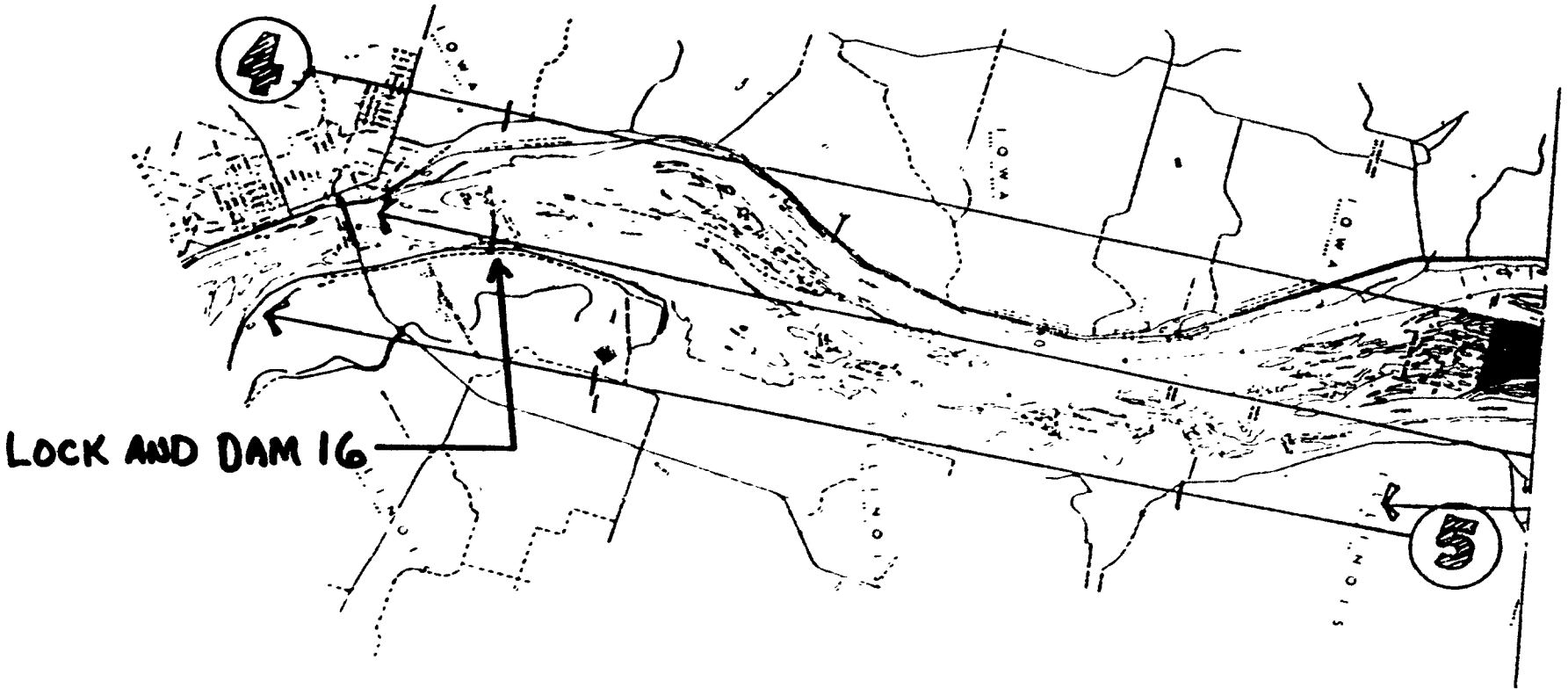


Figure 4-16a Pool 16 Flight Map H' = 2500' AMT
Scale: 1" = 1 mile (shown at reduced scale)
Air Base B = 2460'
25% Endlap

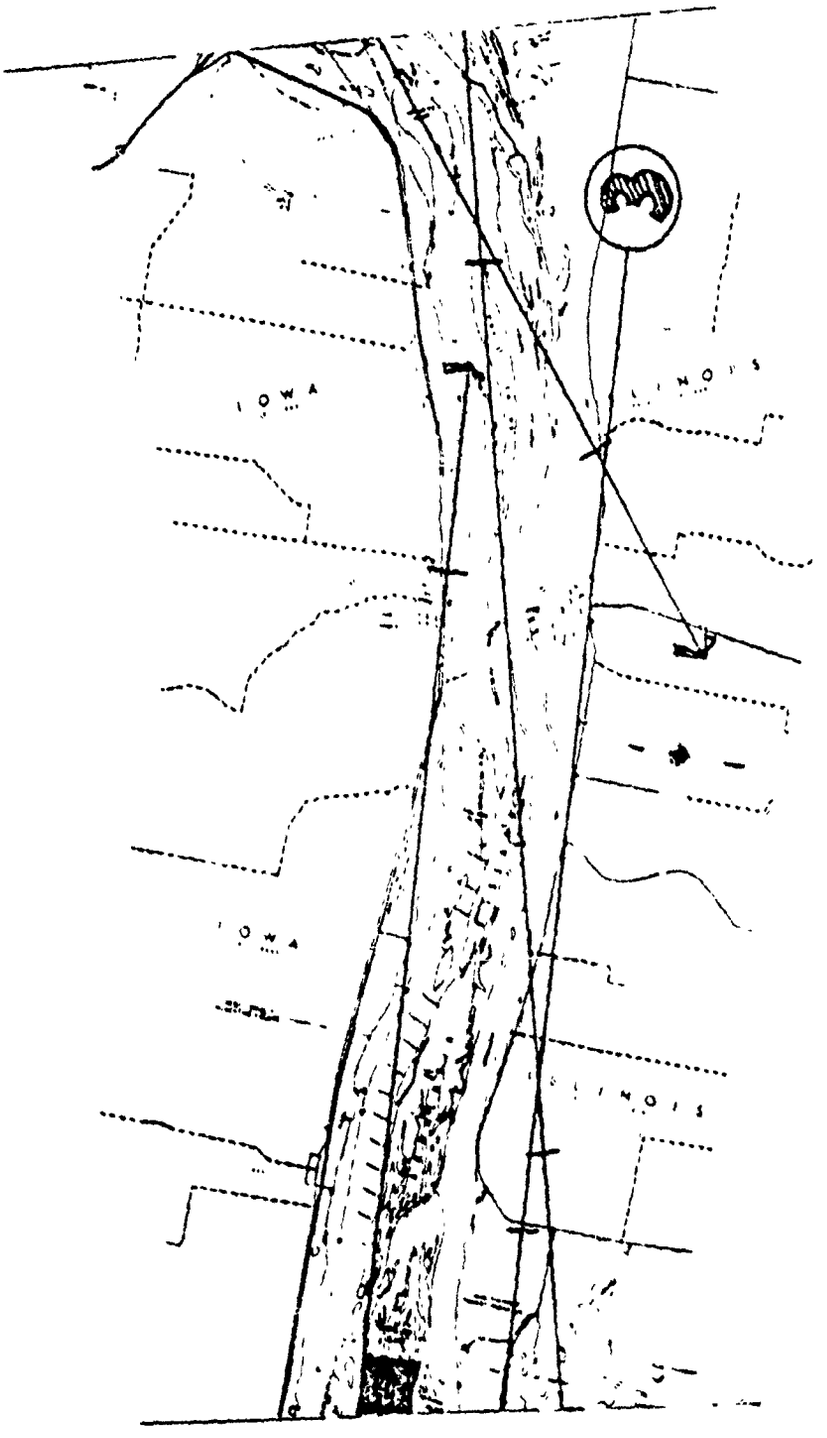


Figure 4-16b

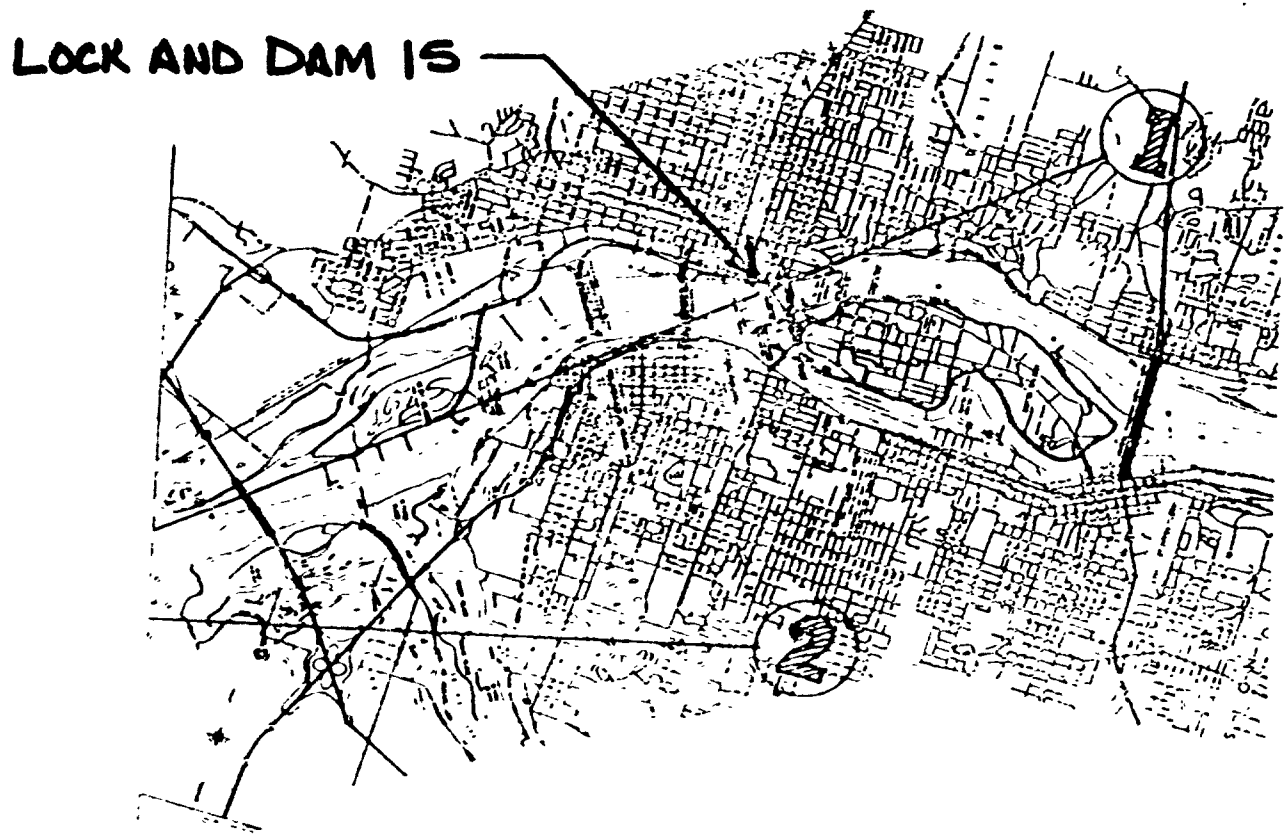


Figure 4-16c

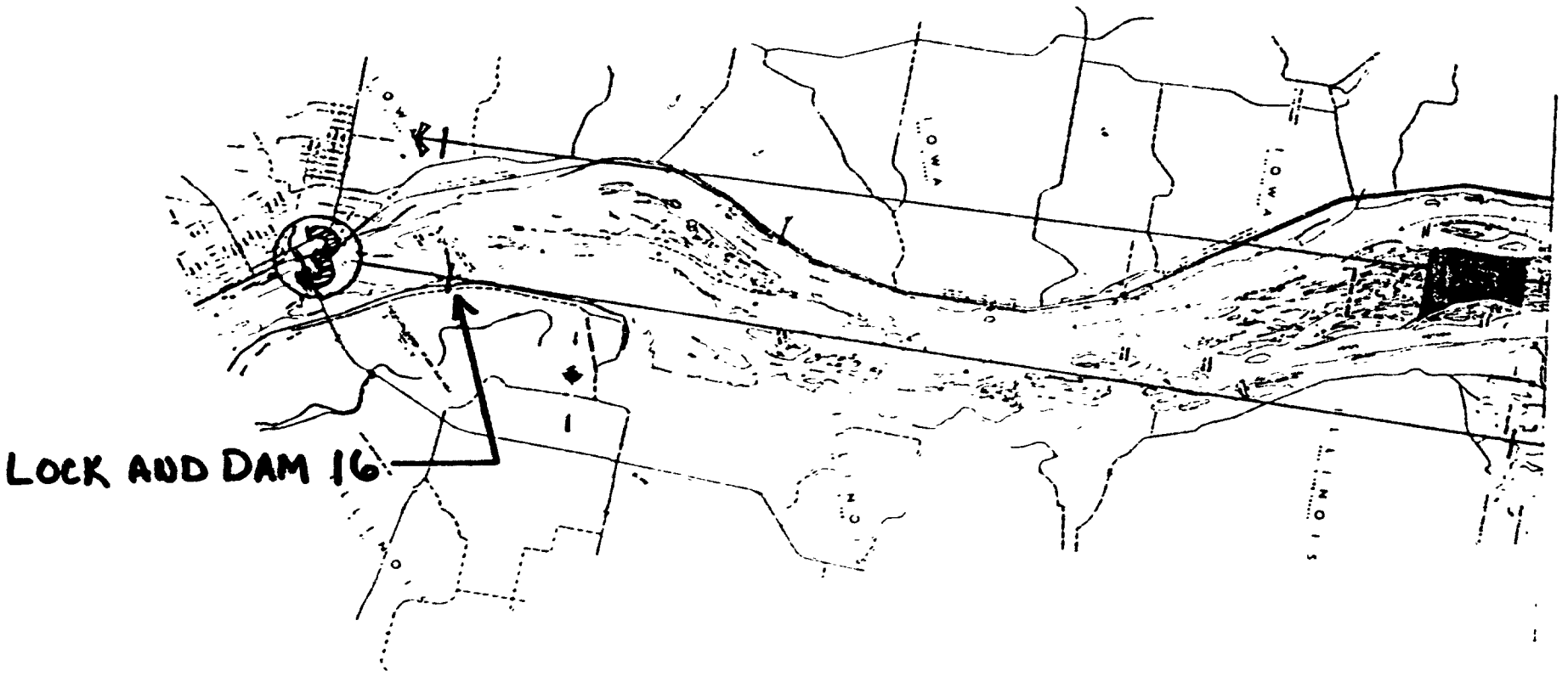


Figure 4-17a Pool 16 Flight Map H' = 3500' AMT
Scale: 1" = 1 mile (shown at reduced scale)
Air Base = 3640'
20% Endlap

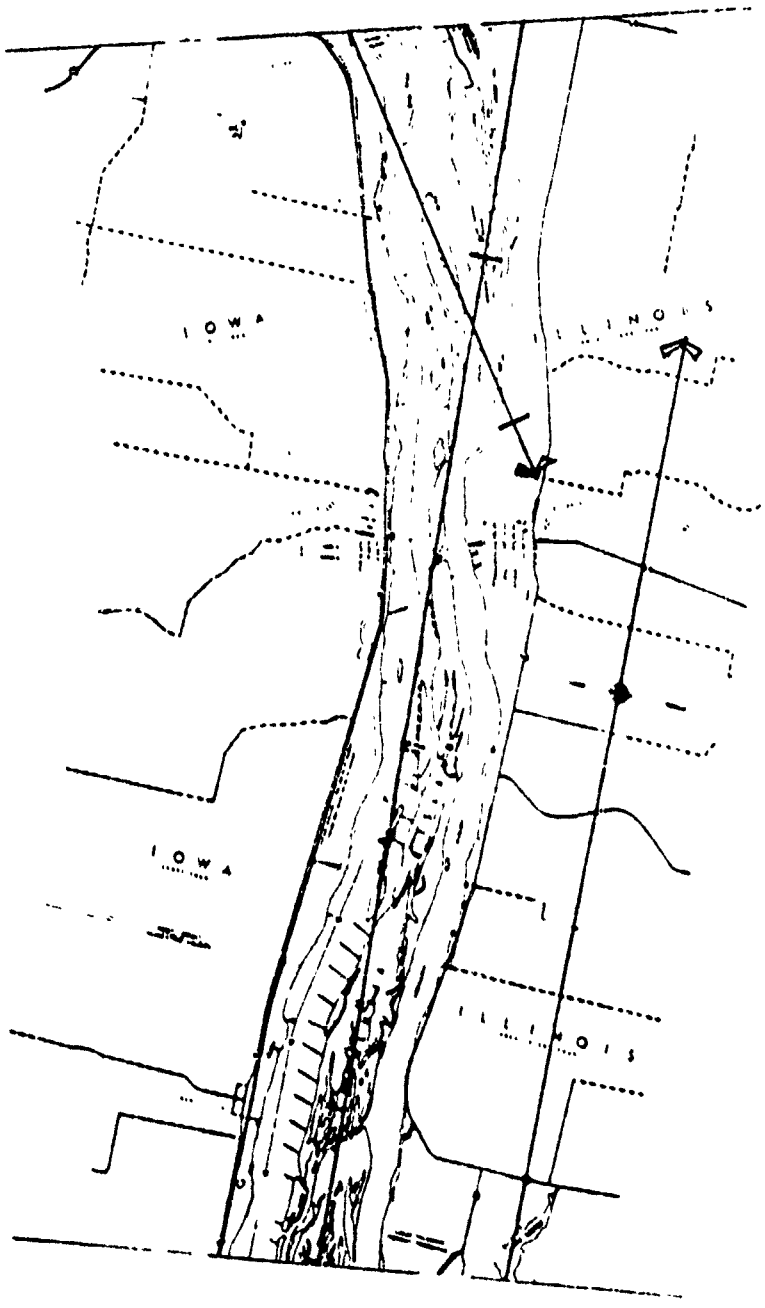


Figure 4-17b

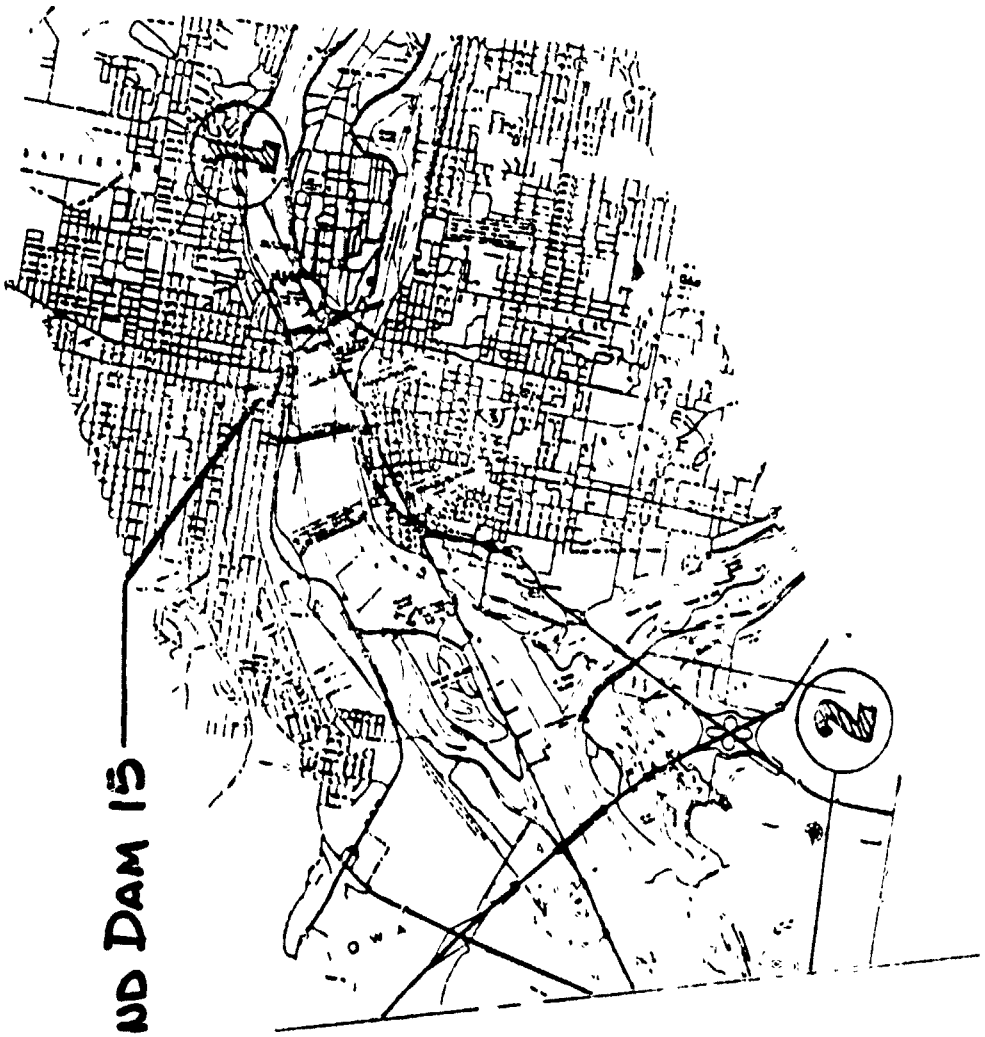


Figure 4-17c

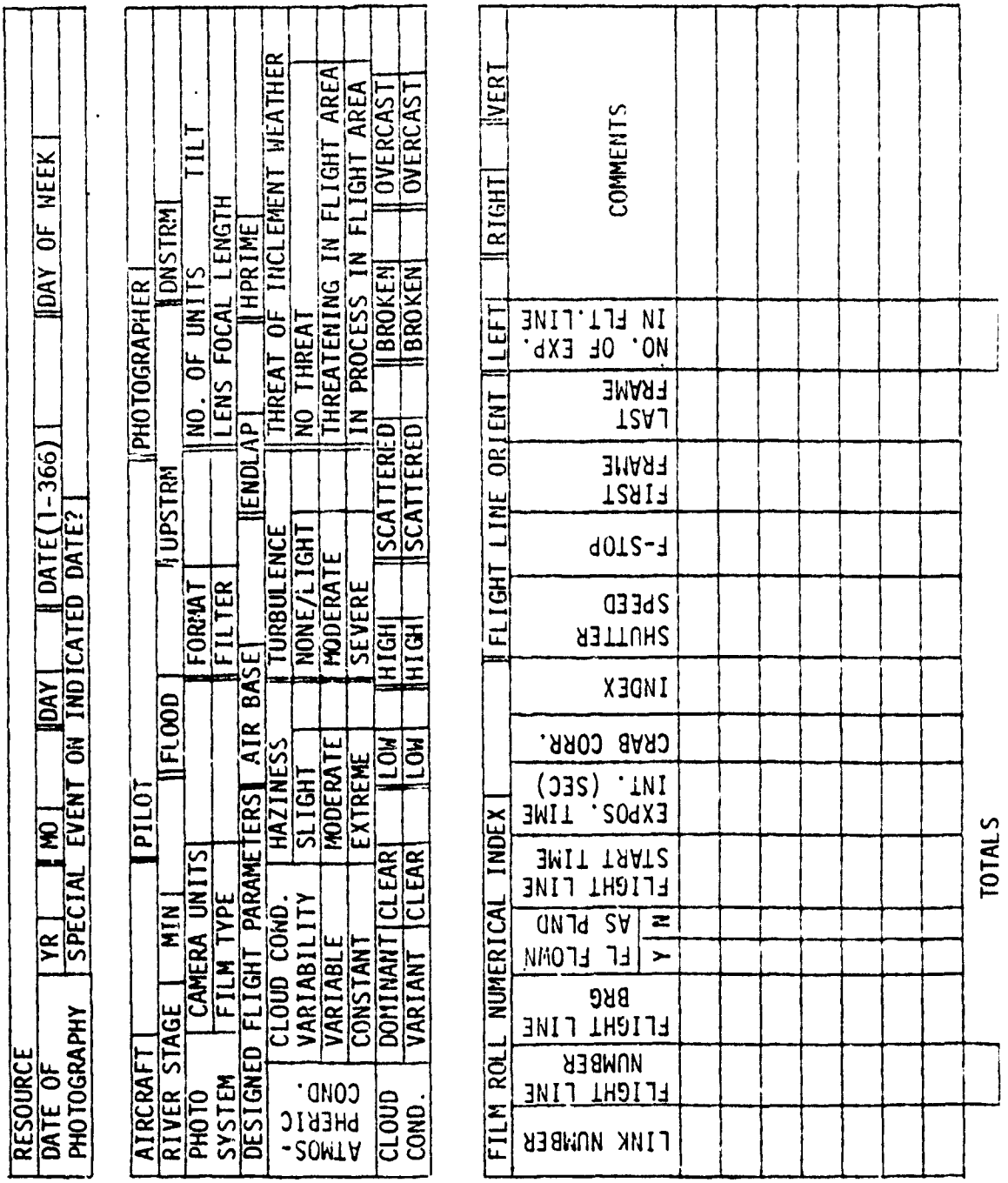


Figure 4-18. Blank flight log form

AERIAL PHOTOGRAPHY LOG

RESOURCE	Pool 16, Mississippi								
DATE OF PHOTOGRAPHY	YR	79	MO	8	DAY	15	DATE(1-366)	227	DAY OF WEEK	WED
	SPECIAL EVENT ON INDICATED DATE?	NONE							

AIRCRAFT	Cessna 180	PILOT	Patenaude				PHOTOGRAPHER	Foyil						
RIVER STAGE	MIN			FLOOD			UPSTRM		DNSTRM					
PHOTO SYSTEM	CAMERA UNITS	HASELBLAD 500ELM		FORMAT	70mm		NO. OF UNITS	2	TILT	19°				
	FILM TYPE	2443(C)/2448(B&W)		FILTER	YELLOW/HAZE		LENS FOCAL LENGTH	40 mm						
DESIGNED FLIGHT PARAMETERS	AIR BASE	2460'		ENDLAP	25%		HPRIME	2500'						
ATMOSPHERIC COND.	CLOUD COND. VARIABILITY		HAZINESS		TURBULENCE		THREAT OF INCLEMENT WEATHER							
	VARIABLE		SLIGHT	X	NONE/LIGHT		NO THREAT	X						
	CONSTANT	X	MODERATE		MODERATE	X	THREATENING IN FLIGHT AREA							
			EXTREME		SEVERE		IN PROCESS IN FLIGHT AREA							
CLOUD COND.	DOMINANT	CLEAR		LOW		HIGH X	SCATTERED	X	BROKEN		OVERCAST			
	VARIANT	CLEAR		LOW		HIGH	SCATTERED		BROKEN		OVERCAST			

FILM ROLL NUMERICAL INDEX									FLIGHT LINE ORIENT				LEFT	RIGHT	VERT
LINK NUMBER	FLIGHT LINE NUMBER	FLIGHT LINE BRG	FL FLOWN AS PLND Y	FL FLOWN AS PLND N	FLIGHT LINE START TIME	EXPOS. TIME INT. (SEC)	CRAB CORR.	INDEX	SHUTTER SPEED	F-STOP	FIRST FRAME	LAST FRAME	NO. OF EXP. IN FLT. LINE	COMMENTS
	1				1419	13	-	(IR) 1/500 (Color) 1/250		5.6	1	20	(20)	
	2				1429						21	34	(13)	
	3				1435						35	58	(23)	
	4				1447						1	35	(34)	
	5				1456						36	46	(11)	
		TOTALS												

Figure 4-19. Sample in-flight flight log (see also figures 4-21a, b, c, and d)

FILM PROCESSING REQUEST

DATE SUBMITTED TO PROCESSOR 16 Aug 1979

BLANKET ORDER NO. ( )

DATE FLOWN? 15 Aug 1979

DELIVER TO: DEPT OF LANDSCAPE ARCHITECTURE
ATTN: KEN FOYIL
25 AGRICULTURE HALL
UNIV. OF WISCONSIN - MADISON
MADISON, WI 53706

FILM DESCRIPTION:

ROLL ID	SIZE	FILM TYPE	SUBJECT
13-A-L	70mm x 15'	2443	POOL 13, MISSISSIPPI RIVER
13-A-R	"	2448	" "
13-B-L	"	2443	" "
13-B-R	"	2448	" "
13-C-L	"	2443	" "
13-C-R	"	2448	" "
16-A-L	"	2443	POOL 16, "
16-A-R	"	2448	" "
16-B-L	"	2443	" "
16-B-R	"	2448	" "
21-A-L	"	2443	POOL 21, "
21-A-R	"	2448	" "
21-B-L	"	2443	" "
21-B-R	"	2448	" "

SPECIAL INSTRUCTIONS: RETURN SHIPMENT TO BE INSURED.

Figure 4-20 Sample Film Processing Request

AERIAL PHOTOGRAPHY LOG

RESOURCE	Pool 16, Mississippi R.										
DATE OF PHOTOGRAPHY	YR	79	MO	8	DAY	15	DATE(1-366)	227	DAY OF WEEK	WED	
	SPECIAL EVENT ON INDICATED DATE?	None									

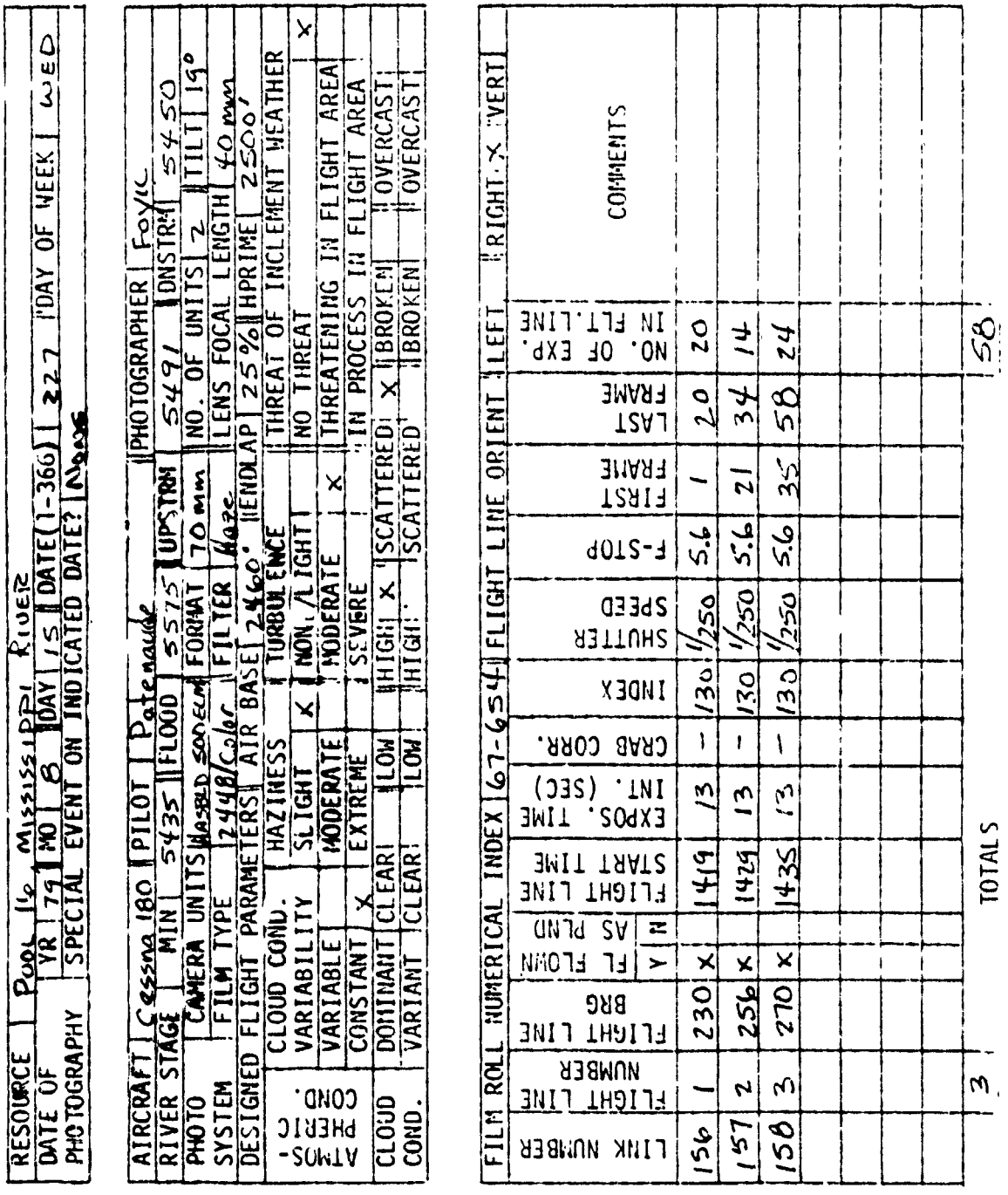
AIRCRAFT	Cessna 180	PILOT	Patenaude				PHOTOGRAPHER	Foyle			
RIVER STAGE	MIN	5435	FLOOD	5575	UPSTRM	5491	DNSTRM	5450			
PHOTO SYSTEM	CAMERA UNITS	Hasbld 500ELM	FORMAT	70 mm	NO. OF UNITS	2	TILT	19°			
	FILM TYPE	2443/Color IR	FILTER	Yellow	LENS FOCAL LENGTH	40 mm					
DESIGNED FLIGHT PARAMETERS	AIR BASE	2460'	ENDLAP	25%	HPRIME	2500'					

ATMOS-PHERIC COND.	CLOUD COND. VARIABILITY		HAZINESS		TURBULENCE		THREAT OF INCLEMENT WEATHER							
			SLIGHT	X	NONE/LIGHT		NO THREAT							X
	VARIABLE		MODERATE		MODERATE	X	THREATENING IN FLIGHT AREA							
	CONSTANT	X	EXTREME		SEVERE		IN PROCESS IN FLIGHT AREA							
CLOUD COND.	DOMINANT	CLEAR		LOW		HIGH X		SCATTERED X		BROKEN		OVERCAST		
	VARIANT	CLEAR		LOW		HIGH		SCATTERED		BROKEN		OVERCAST		

FILM ROLL NUMERICAL INDEX 67-644 FLIGHT LINE ORIENT LEFT X RIGHT VERT

LINK NUMBER	FLIGHT LINE NUMBER	FLIGHT LINE BRG	FL FLOWN AS PLND Y	FL FLOWN AS PLND N	FLIGHT LINE START TIME	EXPOS. TIME INT. (SEC)	CRAB CORR.	INDEX	SHUTTER SPEED	F-STOP	FIRST FRAME	LAST FRAME	NO. OF EXP. IN FLT. LINE	COMMENTS
153	1	230	X		1419	13	-	140	1/500	5.6	1	20	20	
154	2	256	X		1429	13	-	140	1/500	5.6	21	34	14	
155	3	270	X		1435	13	-	140	1/500	5.6	35	58	24	
	3				TOTALS								58	

Figure 4-21a. Sample transcribed aerial photographic log (sheet 1) (see also Figures 4-19 and 4-21b, c, and d)



AERIAL PHOTOGRAPHY LOG

RESOURCE	Pool 11 Mississippi River												
DATE OF PHOTOGRAPHY	YR 79 MO 8 DAY 15 DATE(1-366) 227 DAY OF WEEK WED												
	SPECIAL EVENT ON INDICATED DATE? None												

AIRCRAFT	Cessna 180	PILOT	Patenaude		PHOTOGRAPHER	Foyle							
RIVER STAGE	MIN 5435	FLOOD	5515	UPSTRM	5491	DNSTRM	5450						
PHOTO SYSTEM	CAMERA UNITS	Wasatch Seneca	FORMAT	70 mm	NO. OF UNITS	2	TILT	19°					
	FILM TYPE	2448/Color	FILTER	Haze	LENS FOCAL LENGTH	40 mm							
DESIGNED FLIGHT PARAMETERS		AIR BASE	2460'	ENDLAP	25%	HPRIME	2500'						
ATMOSPHERIC COND.	CLOUD COND.	HAZINESS		TURBULENCE		THREAT OF INCLEMENT WEATHER							
	VARIABILITY	SLIGHT	X	NON. /LIGHT		NO THREAT		X					
	VARIABLE	MODERATE		MODERATE	X	THREATENING IN FLIGHT AREA							
	CONSTANT	X	EXTREME	SEVERE		IN PROCESS IN FLIGHT AREA							
CLOUD COND.	DOMINANT	CLEAR	LOW	HIGH	X	SCATTERED	X	BROKEN		OVERCAST			
	VARIANT	CLEAR	LOW	HIGH		SCATTERED		BROKEN		OVERCAST			

FILM ROLL	NUMERICAL INDEX	67-654	FLIGHT LINE ORIENT	LEFT	RIGHT X	VERT

LINK NUMBER	FLIGHT LINE NUMBER	FLIGHT LINE BRG	FL FLOWN Y	AS PLND N	FLIGHT LINE START TIME	EXPOS. TIME INT. (SEC)	CRAB CORR.	INDEX	SHUTTER SPEED	F-STOP	FIRST FRAME	LAST FRAME	NO. OF EXP. IN FLT. LINE	COMMENTS
156	1	230	X		1419	13	-	130	1/250	5.6	1	20	20	
157	2	256	X		1429	13	-	130	1/250	5.6	21	34	14	
158	3	270	X		1435	13	-	130	1/250	5.6	35	58	24	
	3	TOTALS											58	

Figure 4-21b. Sample transcribed aerial photographic log (sheet 2)
(see also figures 4-19 and 4-21a, c, and d)

AERIAL PHOTOGRAPHY LOG

RESOURCE	Pool 16 Mississippi River								
DATE OF PHOTOGRAPHY	YR	79	MO	8	DAY	15	DATE(1-366)	227	DAY OF WEEK	WED
	SPECIAL EVENT ON INDICATED DATE?	None							

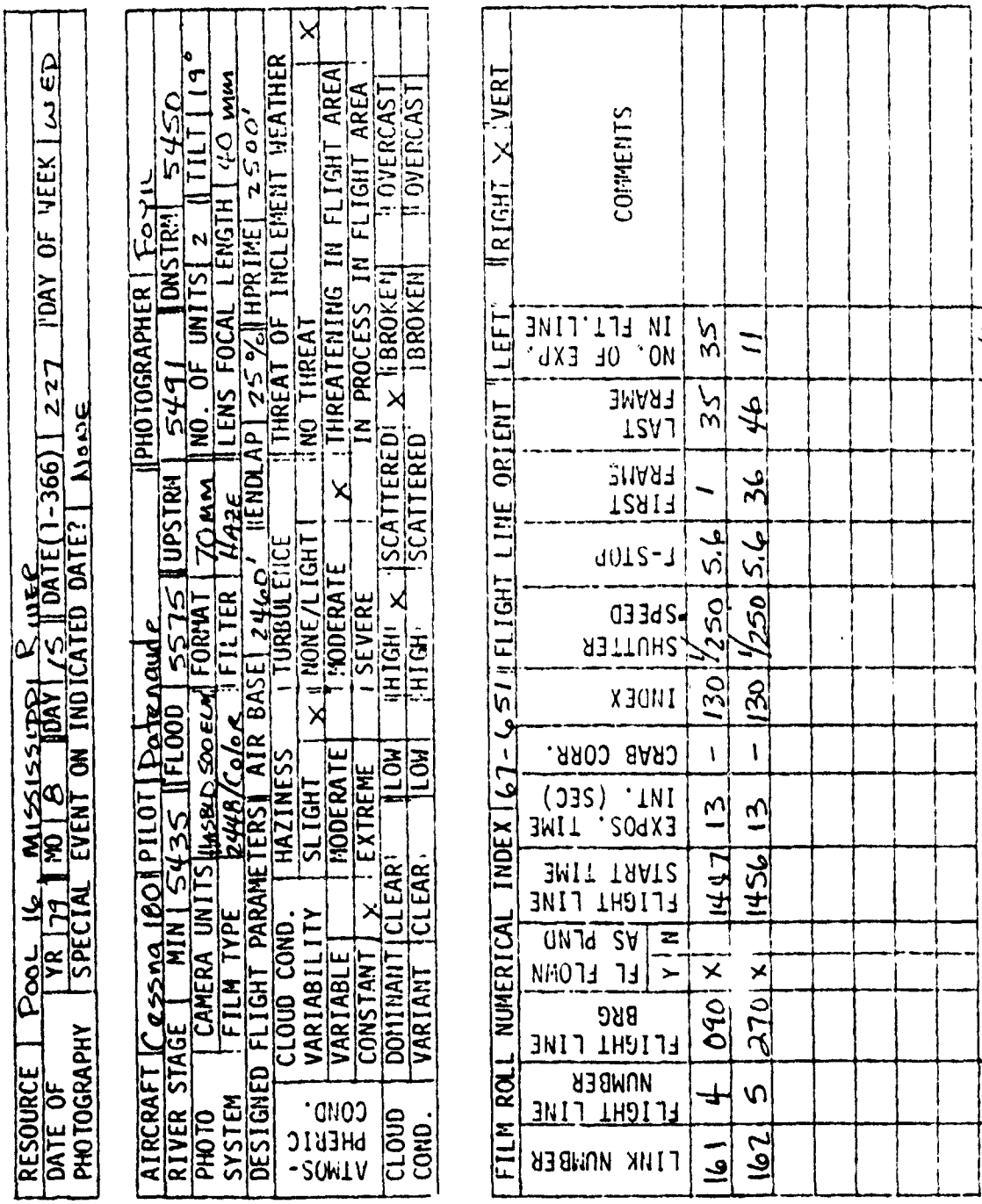
AIRCRAFT	Cessna 180	PILOT	Patenaude				PHOTOGRAPHER	Foyle			
RIVER STAGE	MIN	543.5	FLOOD	557.5	UPSTRM	549.1	DNSTRM	545.0			
PHOTO SYSTEM	CAMERA UNITS	Hasblad 500ELM	FORMAT	70mm	NO. OF UNITS	2	TILT	19°			
	FILM TYPE	2443/Color IR	FILTER	Yellow	LENS FOCAL LENGTH	40 mm					
DESIGNED FLIGHT PARAMETERS	AIR BASE	2460'	ENDLAP	25%	HPRIME	2500'					

ATMOSPHERIC COND.	CLOUD COND. VARIABILITY		HAZINESS		TURBULENCE		THREAT OF INCLEMENT WEATHER	
	VARIABLE		SLIGHT	X	NONE/LIGHT		NO THREAT	X
	CONSTANT	X	MODERATE		MODERATE	X	THREATENING IN FLIGHT AREA	
			EXTREME		SEVERE		IN PROCESS IN FLIGHT AREA	
CLOUD COND.	DOMINANT	CLEAR	LOW	HIGH	X	SCATTERED	X	BROKEN		OVERCAST	
	VARIANT	CLEAR	LOW	HIGH		SCATTERED		BROKEN		OVERCAST	

FILM ROLL NUMERICAL INDEX: 67-643 | FLIGHT LINE ORIENT: LEFT X | RIGHT | VERT

LINE NUMBER	FLIGHT LINE NUMBER	FLIGHT LINE BRG	FL FLOWN Y	FL FLOWN AS PLND	FLIGHT LINE START TIME	EXPOS. TIME INT. (SEC)	CRAB CORR.	INDEX	SHUTTER SPEED	F-STOP	FIRST FRAME	LAST FRAME	NO. OF EXP. IN FLT. LINE	COMMENTS
159	4	090	X		1447	13	-	140	1/500	5.6	1	35	35	
160	5	270	X		1456	13	-	140	1/500	5.6	36	46	11	
	2				TOTALS								46	

Figure 4-21c. Sample transcribed aerial photographic log (sheet 3) (see also figures 4-19 and 4-21a, b, and d)



AERIAL PHOTOGRAPHY LOG

RESOURCE	Pool 16 Mississippi River							
DATE OF PHOTOGRAPHY	YR 79	MO 8	DAY 15	DATE(1-366) 227	DAY OF WEEK WED			
	SPECIAL EVENT ON INDICATED DATE? None							

AIRCRAFT Cessna 180	PILOT Potenaude	PHOTOGRAPHER Fort	
RIVER STAGE MIN 5435	FLOOD 5575	UPSTRM 5491	DNSTRM 5450
PHOTO SYSTEM CAMERA UNITS Hasselblad 500 ELM	FORMAT 70mm	NO. OF UNITS 2	TILT 19°
FILM TYPE 2448/Color	FILTER Haze	LENS FOCAL LENGTH 40 mm	
DESIGNED FLIGHT PARAMETERS AIR BASE 2460'	ENDLAP 25%	HPRIME 2500'	

ATMOSPHERIC COND.	CLOUD COND.	HAZINESS	TURBULENCE	THREAT OF INCLEMENT WEATHER
	VARIABILITY	SLIGHT X	NONE/LIGHT	NO THREAT X
	VARIABLE	MODERATE	MODERATE X	THREATENING IN FLIGHT AREA
	CONSTANT X	EXTREME	SEVERE	IN PROCESS IN FLIGHT AREA
CLOUD COND.	DOMINANT	CLEAR	LOW	HIGH X	SCATTERED X	BROKEN	OVERCAST
	VARIANT	CLEAR	LOW	HIGH	SCATTERED	BROKEN	OVERCAST

FILM ROLL NUMERICAL INDEX 67-651	FLIGHT LINE ORIENT	LEFT	RIGHT X	VERT

LINK NUMBER	FLIGHT LINE NUMBER	FLIGHT LINE BRG	FL FLOWN AS PLND Y	FL FLOWN AS PLND N	FLIGHT LINE START TIME	EXPOS. TIME INT. (SEC)	CRAB CORR.	INDEX	SHUTTER SPEED	F-STOP	FIRST FRAME	LAST FRAME	NO. OF EXP. IN FLT. LINE	COMMENTS
161	4	090	X		1447	13	-	130	1/250	5.6	1	35	35	
162	5	270	X		1456	13	-	130	1/250	5.6	36	46	11	
2													46	TOTALS

Figure 4-21d. Sample transcribed aerial photographic log (sheet 4) (see also figures 4-19 and 4-21a, b, and c)

Kodak Aerial Films

TABLE 4-1. Acquisition/Interpretation Suitability Matrix for Aerial Films vs. Operational/Resource Factors

	FILM TYPE (KODAK)								
	BLACK AND WHITE NEGATIVE							COLOR REVERSAL	
FACTORS	2402 (Pan)	2403 (Pan)	2405 (Pan)	3410 (Pan)	3411 (Pan)	3414 (Pan)	2424 (IR)	2448 (True)	2443 (IR)
Interpretation w/o direct positive B/W processing	3	3	3	3	3	3	3	1	1
Interpretation w/direct positive B/W processing	1	1	1	1	1	1	1	1	1
(Film only) Extremely high resolution	2	2	2	1	2	1	?	2	2
High resolution (coupled w/lens/filter system)	2	2	2	2	2	2	2	2	2
Reduced illumination conditions	1	1	1	2	1	?	1	2	2
Highly variant illumination	2	1	1	3	3	3	1	2	3
Vertical imagery spectral differentiation	1	1	1	1	1	1	1	1	1
Oblique imagery spectral differentiation	3	3	3	3	3	3	3	1	1

LEGEND: 1 Appropriate (High Reliability - Minimal Deviation)

2 Marginally Appropriate (Moderate Reliability - Acceptable Deviation)

3 Inappropriate (Low Reliability - Unacceptable Deviation)

? Unknown

TABLE 4-2. Image Resolvability

Assume best resolution of 30 line pairs/mm for 70mm operational configuration.

Ground resolution cell size at approximate scales:

Scale (fpi)	Ground Resolution (at 30lp/mm) in ft.
500	0.65 ft.
1000	1.3 ft.
1500	2.0 ft.
2000	2.6 ft.
2500	3.3 ft.
3000	3.9 ft.
3500	4.6 ft.
4000	5.2 ft.
4500	5.9 ft.

TABLE 4-3. Aerial Photography Record (1979) by Pool, Date and Time of Day

Pool	Date	Daywk		Holiday Period	Time of Day	No. of Rolls	No. of Flt. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
		Wend	Wday						
11	Aug 11	x			0910-0925	9 x 9	3	18	-
11	Sep 8	x			1440-1520	4	10	142	3500
11	Oct 27	x			1105-1155	4	10	158	3500
12	Aug 11	x			0940-0950	9 x 9	3	14	-
12	Sep 8	x			1210-1240	2	8	108	3500
12	Oct 27	x			1200-1230	2	10	102	3500
13	May 26	x		x	1025-1140	6	12	274	2500
13	Jun 21		x		1010-1105	4	10	140	3500
13	Jul 4		x	x	1127-1225	4	10	144	3500
13	Aug 11	x			1000-1035	9 x 9	3	24	-
13	Aug 11	x			1415-1525	6	12	260	2500
13	Aug 15		x		1645-1755	6	12	258	2500
13	Sep 2	x		x	1435-1525	4	10	148	3500
13	Sep 8	x			1110-1205	4	10	146	3500
13	Sep 15	x			1325-1425	6	12	252	2500
13	Oct 27	x			1425-1510	4	10	146	3500
14	Aug 11	x			1035-1050	9 x 9	5	15	-
14	Aug 25	x			1805-1835	2	10	100	3500
14	Sep 8	x			1025-1100	2	10	102	3500
14	Oct 27	x			1515-1550	2	10	112	3500
15	Aug 11	x			1950-1955	9 x 9	2	7	-
15	Aug 25	x			1750-1800	2	4	34	3500
15	Oct 27	x			1725-1735	2	4	38	3500
16	May 28		x	x	0920-0955 1220-1310	6	14	216	2500
16*	Jun 21		x		1130-1425	2	6	110	3500
16*	Jul 4		x	x	1550-1615	2	6	116	3500
16*	Aug 11	x			1055-1110	9 x 9	4	11	-
16*	Aug 12	x			1500-1540	4	10	202	2500

TABLE 4-3. Aerial Photography Record (1979) by Pool, Date and Time of Day (continued)

Pool	Date	Daywk		Holiday Period	Time of Day	No. of Rolls	No. of Flt. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
		Wend	Wday						
16*	Aug 15		x		1420-1500	4	10	208	2500
16	Sep 2	x		x	0955-1020	2	6	116	3500
16	Sep 8	x			0955-1025	2	6	110	3500
16*	Sep 15	x			1450-1535	4	10	206	2500
16	Oct 27	x			1735-1800	2	6	112	3500
17	Jul 4		x	x	1455-1525	2	8	110	3500
17	Jul 29	x			1455-1525	2	8	122	2500
17	Aug 11	x			1110-1120	9 x 9	3	8	-
17	Aug 11	x			1605-1635	2	8	124	2500
17	Aug 15		x		1155-1220	2	8	122	2500
17	Aug 25	x			1715-1745	2	8	112	3500
17	Sep 2	x		x	1330-1410	2	8	118	3500
17	Oct 28	x			1610-1640	2	8	112	3500
18	Aug 11	x			1120-1130	9 x 9	4	10	-
18	Aug 25	x			1445-1525	2	10	128	3500
18	Oct 28	x			1445-1525	2	10	130	3500
19	Aug 11	x			1130-1150	9 x 9	7	23	-
19	Aug 25	x			1335-1445	4	22	204	3500
19	Oct 28	x			1340-1445	4	22	224	3500
20	Aug 11	x			1150-1200	9 x 9	2	8	-
20	Aug 25	x			1120-1135	2	4	62	3500
20	Oct 28	x			1200-1215	2	4	64	3500
21	May 28		x	x	1350-1500	4	8	208	2500
21	Jun 21		x		1355-1500	2	6	104	3500
21	Jul 29	x			1600-1640	4	8	202	2500
21	Aug 11	x			1200-1205	9 x 9	2	7	-
21	Aug 12	x			1217-1255	4	8	204	2500
21	Aug 15		x		1025-1105	4	8	198	2500
21	Aug 25	x			1050-1115	2	6	114	3500

TABLE 4-3. Aerial Photography Record (1979) by Pool, Date and Time of Day (continued)

Pool	Date	Daywk Wend	Daywk Wday	Holiday Period	Time of Day	No. of Rolls	No. of Flt. Lines	No. of Exposures	Flight Altitude AMT (70mm only)
21	Sep 2	x		x	1115-1145	2	6	110	3500
21	Sep 15	x			1720-1755	4	8	200	2500
21	Oct 28	x			1130-1200	2	6	110	3500
22	Aug 11	x			1205-1220	9 x 9	5	13	-
22	Aug 25	x			1025-1050	2	8	76	3500
22	Oct 28	x			1105-1130	2	8	80	3500

Notes:

1. Both 70mm and 9" x 9" imagery entries are included.
2. Flight altitudes are reflected for 70mm imagery only.
3. All 9" x 9" imagery flown on August 11, 1979.
4. Total number of 70mm pool flights: 51.
5. Total number of 70mm rolls: 156.
6. Total number of 70mm flight lines (flight map x 2): 456.
7. Total number of 70mm exposures (in-flight log x 2): 7294.
8. Total number of 9" x 9" exposures: 158.
9. Flight time over pool approximated by the time of day entry.
10. Time of day expressed in terms of 24 hour clock.
11. Pool 16 flight dates marked with an asterisk (*) were those selected for interpretation.
12. May 28 flight over pool 16 had non-continuous coverage - the delay from 0955 to 1220 a result of trouble-shooting camera system.

APPENDIX 4.A

9" x 9" Contract Flight Bid Specifications

STATE OF WISCONSIN

RETURN TO: UNIVERSITY OF WISCONSIN-MADISON
PURCHASING DEPARTMENT
750 UNIVERSITY AVE
MADISON, WISCONSIN 53706

REQUEST FOR QUOTATION

THIS IS NOT AN ORDER

The University is exempt from all Federal, State and local excise and sales taxes. Contractors performing construction activities will pay State Use Tax on the cost of materials.

Data requested by the University are not considered by the Wisconsin Fair Trade Act.

Substitutions may be bid, but MUST be described by manufacturer and stock number. The University shall be sole judge of equivalency.

Show net price on quantity items bid. If bid requires is not firm, state conditions fully.

In determination of award, cash discounts will not be considered except in case of tie.

No formal bid over $3000 can be accepted except in formal sealed bids.

The right is reserved to accept or reject all or part of a proposal submitted, and to accept such bid deemed in the best interests of the State of Wisconsin.

SEE OTHER SIDE

R. S. Farnsworth
University Purchasing Administrator

For further information concerning this inquiry, contact:

C. W. Ebert

Telephone Area 608 262-1522

your reply please refer to Inquiry No. F0-4750
PKC Date 07-05-79

SEALED BID

quotations MUST be in this office not later than 07-19-79, 2:00 PM CDST

note price and delivery FOB DESTINATION, DOOR DELIVERY:
(X) Madison, Wisconsin
( )

Delivery MUST be shown

ENTITY	UNIT	ARTICLE	DELIVERY IN DAYS	UNIT PRICE	TOTAL NET PRICE
		Aerial vertical photography, scale of 2,000 ft. to one inch or greater on infra-red color reversal film for reconnaissance surveys of an area along the Mississippi River extending for Lock and Dam 10 at Guttenberg, Iowa, south to Lock and Dam 22 southeast of Saverton, Missouri, to include processing and delivery of film, delivery of one copy of flight map(s) used in obtaining subject aerial photography, and delivery of written statement of atmospheric, light and flight conditions and parameters to contracting authority. Advise cost of the performance bond _____/$1000.00. Questions regarding the invitation to bid should be directed to Ken Foyil, home phone (608)831-6180, departmental phone (608)263-7300 (Department of Landscape Architecture.)			$

remarks: _____

Delivery: FOB Destination, Door Delivery

Terms: _____ Date _____

Signed: _____

Title: _____

SALESMEN'S HOURS: 9:00-11:30 A.M., 1:00-3:00 P.M., MONDAY THRU FRIDAY

THE UNIVERSITY OF WISCONSIN - Madison

Inquiry ED-4740
Page 1

SPECIFICATIONS - GENERAL REQUIREMENTS AND CONDITIONS:

Performance Bond - The successful bidder may be required to furnish a performance bond prescribed by the contracting authority in a sum of less than the total amount bid. The performance bond cost must be listed separately on the bid form.

Competency/Qualifications - The bidder must furnish the contracting authority information relating to his qualifications and competency. This information shall include a certified statement setting forth the bidder's business and technical organization, experience in aerial photography, equipment available for the bid project, whether or not he has conducted prior aerial photography (for others) of project area, and other information he deems qualifying. Details and sample photography on prior photography of the project area should be submitted if possible.

Examination - Before an agreement is entered into, the successful bidder shall carefully examine the itemization schedule, specifications, and associated drawings, plans and maps. It shall be his responsibility to obtain sufficient knowledge of the project area and all conditions affecting agreement work and its performance, including applicable laws, ordinances and regulations. One set of all available USGS topographical maps (scales of 1:24,000, 1:62,500 and 1:250,000), river navigation charts (scale of 1:31,680), and associated drawings/plans of the project area will be available for examination at Room 254, Peterson Office Building, University of Wisconsin-Madison campus, during regular business hours. Cross-hatched quad areas on attached project area map are not mapped by USGS. Orthophotoquads exist for those areas, but are not available at the above-cited office.

Plan for Agreement Work - The bidder shall submit a plan for agreement work, which shall include:

A. Information on qualifications and competency as referenced above.

B. The type of aerial camera to be used, the lens' focal length and characteristics of the lens including maximum tangential distortion, and the radial distortion, measured in millimeters, relative to the calibrated focal length at the angles specified in the lens' current calibration report.

C. Anticipated delivery time to the contracting authority of end item products in terms of number of days beyond the date of completion of aerial photography, said number of days not to exceed thirty (30).

Preparation of Itemization Schedule - Bid amount shall be written legibly (in ink or typewritten), on form provided by the contracting authority, as a lump sum and cost of performance bond listed separately. The schedule and any alterations must be on letterhead stationery, signed by the bidder or this authorized representative and attached to the bid.

Intent of Agreement - The intent of the agreement is to prescribe the entire agreement work which the successful bidder shall undertake to complete. The successful bidder shall furnish whatever service and/or goods are necessary for the satisfactory completion of agreement work.

Items - End item products to be delivered to the

A. Processed film of subject aerial vertical photography in continuous strip form on spool(s).

B. One (1) set of flight maps upon which the flight lines are delineated. Flight lines shall reflect direction of flight, flight sequence, and tick marks for inten exposure stations.

C. Written statement of atmospheric, light and flight conditions and parameters during execution of subject aerial photographic work.

Control of Work and Materials Ownership - Processed film of subject aerial photography and other required end items shall all become the property of the contracting authority. While any items of agreement work are in the possession of successful bidder and until certified delivery of same to contracting authority, the successful bidder is responsible for their preservation. Should any items become lost, damaged, or destroyed within that period, for any reason, the successful bidder shall replace them at the earliest possible date acceptable to and without cost to the contracting authority.

Time of Photography - Photography shall be taken during a weekend period, between the hours of 9 AM and 6 PM. Photography shall be over one weekend period only and preferably over one day. If photography must be split over a two day period, justification for doing so shall appear in the written statement of flight conditions and parameters. Weekend periods acceptable for execution of aerial photography are: 7-8 July 1979, 14-15 July 1979, 21-22 July 1979, or 28-29 July 1979. After notice to proceed, the successful bidder shall execute aerial photography at the earliest possible date that projected atmospheric conditions will allow aerial photographic coverage of the area with no more than two (2) percent of the total imagery (in terms of numbers of frames) obscured, whether partially or wholly, by cloud cover to the extent that ground features are not discernible. Dates other than those indicated must be negotiated with the contracting authority and justifiable only because of adverse weather conditons on dates indicated. If more than two (2) percent of the total imagery is obscured as defined above, such may be cause for rejection of the photography of the pool over which it occurs.

Rejected Agreement Work - All agreement work which does not meet agreement requirements and is rejected by the contracting authority will be corrected to fully conform, if such is possible without reflying the photography. The costs of such work shall be borne by the successful bidder.

Legal Responsibility - The bidder is assumed to be familiar with and at all times comply with all Federal, State, and local laws, safety laws, and regulations affecting agreement work. The successful bidder shall take necessary care at all times, in all operations and use of his equipment, to protect the public, and shall exercise reasonable precautions for the safety of employees on the project. Whenever any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, or neglect of the successful bidder during execution of agreement work, or as the consequence of non-execution thereof on the part of the successful bidder, the successful bidder shall save harmless the contracting authority and representatives thereof from all suits, actions, or claims of any kind brought on account of said injury or damage.

Aerial Vertical Photography Specification Details Area - The area to be photographed is a narrow longitudinal area approximately 315 river miles long (see attached project area map). Aerial photographic coverage will extend from lock and Dam 10 to Lock and Dam 22, as indicated in the itemization schedule. Minimum width coverage shall be from levee to levee, railroad track to railroad track, or levee to railroad track on either side of the river, whichever delineates the narrowest area. Where no levee or railroad track is present along the shoreline of the river, a straight line joining the ends of such applicable features shall delineate the width of coverage for such affected area.

Film - Only color reversal type infrared film having an emulsion of fine grain, high sensitivity, and high intrinsic resolving power shall be used. Out-dated film shall not be used.

Camera and Associated Equipment - A single lens camera shall be used, and shall be equipped with vacuum system or pressure device for holding the film flat during exposure and an intervalometer for automatic operation. Format shall be 9-inch by 9 inch. The camera must produce fiducial marks on each frame for accurately locating the principal point. The camera shall be capable of exposing sequential frame numbers onto the film. Frame numbers shall be sequential within each roll of film and flight maps(s) shall identify the area covered by each roll. If more than one roll is necessary. If the camera not expose the time (of day) of exposure on the film, the written statement of conditions and parameters shall contain the day and time of day for the first and every fiftieth exposure thereafter. Focal length of the lens shall be at the discretion of the successful bidder. A Wratten #12, or equivalent, filter shall be used.

Photographic Scale - Successful bidder shall be allowed to vary scale, hence flight altitude, of the aerial photography. Minimum scale shall be 2,000 feet to one inch, with flight altitude not to exceed 15,000 feet above mean terrain. The flexibility to underfly low to medium altitude cloud cover, hence conduct the aerial photography in one mission is the prime purpose in allowing a flexible photographic scale. When possible, the 2,000 feet to one inch scale should be used. Variations in flight altitude/photographic scale shall be annotated in the written statement of flight conditions and parameters and on the respective flight map(s).

Flight Lines - Flight lines shall be designed so as to obtain a nominal ten (10) percent endlap and ten (10) percent sidelap, if parallel flight lines are necessary. Elevations of each pool at flood stage (see Appendix A) shall be used as mean terrain elevations for flight line planning purposes. Endlap and sidelap in the resultant imagery must meet the following criteria to be acceptable:

Avg. % endlap or sidelap may be less than	In no more than indicated % of all frame pairs
10	25
5	5

Endlap or sidelap of less than than three (3) percent on any frame pair may be cause for rejection of photography of pool over which it occurs. Camera shall be oriented to flight line in such a way that endlap is observable along adjacent edges of frame pairs. Flight lines may be laid out for operational purposes on any suitable map(s), photomosaic(s), or orthophotograph(s), and shall be labeled as to sequence in which they were flown. If parallel flight lines are required, such coverage shall be made immediately after the line which it parallels. In general, flight lines shall be oriented for most efficient photography in terms of flight time and film used.

Crab - Crab in excess of five degrees may be cause for rejection of the photography of the pool over which it occurs.

Tilt - Tilt in excess of five degrees on any exposure or in excess of two degrees (average) for all imagery may be cause for rejection of the photography of the pool over which it occurs.

Processing of Exposed Film - The processing shall result in imagery free from chemical and other stains, containing normal and uniform density, and fine grain quality. Before, during, and after processing, the film shall not be rolled tightly on drums or spools or in any way stretched, distorted, scratched, or marked, and shall be free from finger marks, dirt or blemishes of any kind.

Quality of Photography - Exposure and processing shall be such that the imagery will be of high quality showing the descriptive detail of planimetric and topographic features discernible at the required scale. Details shall show clearly in both dark-tone and high-light areas. Imagery having excessive contrast may be cause for rejection of the photography of the pool over which it occurs.

Unexposed Film - If a partially exposed roll of film is to remain in the camera subsequent to completion of aerial photography for this project, a minimum of three (3) feet of film shall be rolled forward unexposed immediately upon completion of photography under this project. A minimum of two (2) feet and a maximum of four (4) feet of unexposed film will be allowed for leaders and trailers on each roll of film.

Basis of Payment -

Delivery of End Items - Delivery address of required end items will be indicated on purchase order. Payment of invoice will be made approximately thirty days after acceptance of end items.

Acceptance - Acceptance by the contracting authority will be given by Prof. Robert H. Becker, Dept. of Forestry, and shall be given along with any exceptions, no later than twenty (20) days after receipt of all required end items. Exceptions to the acceptance shall be in writing and adequately justified. Payment withheld for rejected portions of the delivered imagery will be based on the differential operational costs incurred by the successful bidder on the principle that neither party to the agreement work should be penalized.

APPENDIX A

Pool		Flood Stage (Ft. above MSL)
11	(L/D 10 to L/D 11)	615
12	(L/D 11 to L/D 12)	599
13	(L/D 12 to L/D 13)	592
14	(L/D 13 to L/D 14)	583
15	(L/D 14 to L/D 15)	568
16	(L/D 15 to L/D 16)	558
17	(L/D 16 to L/D 17)	549
18	(L/D 17 to L/D 18)	540
19	(L/D 18 to L/D 19)	527
20	(L/D 19 to L/D 20)	494
21	(L/D 20 to L/D 21)	483
22	(L/D 21 to L/D 22)	471

APPENDIX 4.B

Glossary of Terms

axis of tilt: the axis (line) along which the scale on a tilted photography equals that for the equivalent vertical photograph.

isocenter: the point halfway between the principal point and nadir point through which the axis of tilt passes.

nadir point: the point in object space through which a vertical dropped from the exposure station passes (coincident with principal point for a vertical photograph)

object space: ground space, at actual scale, in the form of a Cartesian coordinate system.

principal point: the point of intersection of the fiducial axes, eseentially the photographic center point.

SECTION 5.

REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING

TABLE OF CONTENTS - SECTION 5

	Page
REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING	5-4
OVERVIEW OF AERIAL PHOTOGRAPHIC INTERPRETATION	5-4
Personnel	5-4
Computer Programming	5-4
Airphoto Interpretation	5-4
Data Encoding	5-5
Equipment	5-5
Dedicated Microcomputer	5-5
Digitizer	5-5
Film Viewing System	5-6
Additional Supplies	5-6
Space	5-7
INTERPRETATIVE PROCESSING OF AERIAL PHOTOGRAPHY	5-7
Data Entry and Software Development	5-8
Handbook	5-8
Description of Records	5-8
Flight Line Information	5-8
Target Information	5-9
Ground Control Points	5-10
Writing Records into Storage	5-10
Text Editor	5-10
Display Program	5-11
APPENDIX 5.A	5-21
APPENDIX 5.B	5-26
APPENDIX 5.C	5-30

LIST OF PHOTOGRAPHS AND FIGURES

Page

Photographs

5-1. Interpreting and Digitizing Targets 5-12
5-2. Magnavox Orion Graphics Terminal in Use 5-13
5-3. Magnavox Orion Graphics Terminal 5-14
5-4. Digitizing Cursor Positioned on Film 5-15
5-5. Close-up of Digitizing Cursor Positioned on Film 5-16
5-6. Stereoscope, Film Winders, and Digitizing Cursor 5-17
5-7. Film Winders and Digitizing Cursor (close-up) 5-18
5-8. Work Space for Film Interpretation and Data Encoding 5-19

Figures

5-1. Hardware Configuration 5-20
5.A.1. FLIGHT PROGRAM (Flight Line Encoding) 5-23
5.A.2. BDIGITIZ PROGRAM (Target Encoding) 5-23
5.A.3. ED60R7 PROGRAM (Record Editing) 5-24
5.A.4. QREAD (Retrieve/Display Flight Line Data) 5-24
5.A.5. QREAD7 (Retrieve/Display Target Data) 5-24
5.A.6. SENDMS (Data Transfer) 5-25
5.B.1. An Example of a Data Transfer Log 5-28
5.B.2. SENDMS Program Flow Chart 5-29

REQUIREMENTS FOR AERIAL PHOTOGRAPHIC INTERPRETATIVE PROCESSING

OVERVIEW OF AERIAL PHOTOGRAPHIC INTERPRETATION

Aerial photographic interpretation process can be described in terms of two procedural steps. One, information pertaining to each flight line is encoded. Second, the information pertaining to each target is entered. Both of these data entry operations use an interactive computer based data encoding process.

With each flight line information on such factors as the weather conditions and flying height are entered into a 120 byte physical record. The film images associated with that particular flight line are later analyzed with a zoom stereoscope for recreational features. The target (recreational feature) is identified using the magnification of the zoom stereoscope, its location determined using the Talos digitizer, and its special attributes noted (Photograph 5-1). Then, all this information is stored as one logical record along with the appropriate flight line data in a four part logical record within a file on a magnetic disk.

The distinctive equipment features of the aerial photography processing are the use of a stand alone graphics computer terminal, and the zoom stereoscope mounted over the digitizing tablet. The stand alone computer terminal allows data records to be stored on magnetic disks in relatively small files. The cost of access and risk of operation shutdowns caused by dependence on a main frame computer are reduced. For statistical analysis purposes the files are all merged and maintained on the main frame system.

The zoom stereoscope is mounted over the digitizing surface. As the film to be analyzed is passed in view of the zoom stereoscope, the location of the feature of interest (target) can be digitized. Other information relevant to the target is entered through the graphics terminal keyboard.

Personnel

Computer Programming

At least one person knowledgeable with data entry software should be included in the interpretative team. The computer programmer should have a B.S. in computer programming and be familiar with digitizing hardware and software, standard graphic display terminals, and data organization techniques. The ability to train others in development of software geared to data entry is also a desired skill.

Airphoto Interpretation

Airphoto interpreters should have a combined background in resource management and airphoto interpretation. Knowledge of

resource management is necessary to understand the recreation use patterns and issues that require analysis. Airphoto interpretation training is necessary to know how to interpret the imagery to obtain the desired recreation resource information. Training of other workers would be a primary responsibility of the airphoto interpreter.

Data Encoding

Data encoding can be done by personnel with two years experience in resource management. The person doing the airphoto interpretation in the actual analysis of film would handle a large part of the data encoding. The primary responsibility of the data encoders would be the entry of the flight line information.

Equipment

Dedicated Microcomputer

A magnavox Orion graphics terminal (Photographs 5-2 and 5-3) is the recommended terminal to use for data entry. It is a stand alone terminal. This means software development for data entry programs can be accomplished with the terminal. Data entry software can be loaded and executed by microprocessor in the terminal. This means that a main frame computer need not be accessed. The site at which the data entry and photo interpretation takes place need not be limited by the accessibility to a main frame computer.

To store information obtained by the data entry and digitizing software and hardware, a dual disk drive is used. It is located adjacent to the graphics terminal. Software for the operating system and data entry are maintained on magnetic disks and are loaded into the buffer of the terminal through the disk drives.

Digitizer

The digitizer is a Talos digitizer. This digitizer was accurate to within 3/1000 of an inch. The cursor used should contain a keypad so that data can be entered through the cursor. The digitizing surface should be elevated to table height, so that a person sitting can comfortably operate it. The Bausch and Lomb Air-Float stool allows the operator to adjust the sitting height. This is helpful in alleviating fatigue.

The recommended cursor (Photographs 5-4 and 5-5) contains the crosshairs to indicate the point digitized and a keyboard to encode alpha-numeric information to the data entry software.

Film Viewing System

The film viewing system consists of a light table, a clean, see-through digitizing surface, a zoom stereoscope, and a pair of film winders (Photographs 5-4 and 5-5). The light table is positioned underneath the surface of the digitizing tablet. The digitizing tablet must be clear enough to allow light to penetrate through and illuminate the film.

The magnification apparatus should be the Bausch and Lomb stereoscope with mono viewing capability. The mono head should be used along with viewing through both eye pieces. This prevents eye strain as both eyes are being used.

The film is wound between two winders (Photographs 5-6 and 5-7). These winders come with a Richards light table. They slide on a bar to allow different film sizes to be mounted.

A roll of film is mounted in one winder and the free end of the film roll taped to the empty spool in the other winder. The film is wound frame by frame as the operator scans the imagery for targets. The operator need not look through the stereoscope always to scan the frame for targets.

The recommended magnification device is the Bausch and Lomb Zoom Stereo Viewer (Photograph 5-6). The distinctive features are its zoom capability, 30x magnification capability, and the ability to look at a single image using both eyes. The stereo viewer is mounted along with the film winders to an H-shaped frame (Photograph 5-6). The stereo viewer is attached to this frame by means of an adjustable boom.

Additional Supplies

Besides the main pieces of hardware, the interpretation team should have on hand the following equipment:

1) magnetic storage disks - as a rough estimate there should be at least two magnetic disks per flight line.

2) USGS quad maps - a complete set of USGS quad maps covering the study area should be acquired.

3) mylar sheets - matte finish mylar sheets 18" x 25" in size should be acquired to overlay the quad maps. The control points are drawn on these sheets. Each quad map for each flight line should have a mylar overlay to indicate control points.

4) signal dots - paper, self-adhesive, 1/4" stick on dots should be acquired to label frames of film.

5) drawing/drafting supplies - pencils, masking tape, lead sharpeners must be on hand for control point labeling and general labeling.

6) thin sheet plexiglass - a 10" x 10" piece of 1/4" thick plexiglass should be acquired to put over the film being analyzed.

Space

The space required is a room 40' x 40' in size. The space should be quiet and free from distractions. Capability to dim the lights is desirable to allow the film to be illuminated better. There should be adequate storage space to store film, magnetic disks, quad maps, mylar and other accessories (Photograph 5-8). You should be able to lock the room to provide security for the hardware and the film.

INTERPRETATIVE PROCESSING OF AERIAL PHOTOGRAPHY

Processing of aerial photography is accomplished by an interpreter using the equipment depicted in Figure 5-1. The line from the RS232 Dual Interface to UNIVAC 1100/80 is a communications interface used after the completion of interpretation. Data transmitted to the UNIVAC 1100/80 is accumulated for statistical analysis.

The interpretation process in general proceeds with an interpreter using the cursor and digitizer to locate targets on film which has been placed on the digitizer surface for examination through the zoom stereoscope. The process is further disciplined by use of the ORION system. During the process the interpreter interacts with software developed for the ORION answering questions as prompted about the target being digitized. The digitizer is also connected to the ORION and the XY position of the target is transmitted to the ORION software which stores the information on disk target by target. In this way a very complete and detailed machine readable data base is created eliminating all of the transcription, coding and time delays associated with purely manual approaches.

The software developed for interpreting and all other processing aspects are described in Appendix A and listings are included in Book 8.

Data Entry and Software Development

Handbook

A handbook describing the procedures used in operating the interpretation equipment, the rules for encoding each variable, and interpretation rules to follow when analyzing the imagery was developed before any image analysis began. This document is located at the end of the report.

Description of Records

The unit of analysis is the target. A target is a feature of interest that has various attributes. For example, duckblinds and various boat types are targets. Their location in the river are the attributes or variables of the target. For each target there are four types of information:

1) Information about the flight line. For example, flying height and weather conditions.

2) Target type and location.

3) The ground control points of the film frame.

4) Properties of the target such as movement and confidence in interpretation.

This information is all contained in one logical record.

Flight Line Information

Flight line information is encoded separately from the target data. Data entry software, called the ENTER program, is used to store the data in the disk file called FORTØ6.DAT. The ENTER program (see the Handbook) automatically prints messages that tell the person which variable should be encoded. For each variable encoded through the ENTER program, the program will not accept values outside of the range that is specified as being unacceptable. Error messages are printed on the screen and the person encoding the data has a chance to encode the value again for the variable. This feature greatly minimizes encoding errors. See the Handbook for a list of the flight line variables.

The LINK variable is a unique identification number used to associate the flight line data with the appropriate set of targets within a particular flight line on a roll of film.

Target Information

Targets have two types of information associated with them: 1) the location of the target, and 2) the properties of the target (apart from location). To obtain the location of the target the interpreter digitizes the location of the target on the imagery. This locational information is expressed as an XY coordinate, with distances from the origin measured in inches. The origin is taken as the lower left corner of the film.

Properties of the target can be further broken down into two classes: the confidence the interpreter has in determining the type of target it is and a varied list of properties of the target. After the interpreter digitizes the location and identifies the target, the interpreter enters information about the confidence of the identification of the target. Three levels of confidence in the interpretation are measured: very sure, educated guess, and very unsure. This data is encoded under the CONF variable. If the interpreter indicated the identification was an educated guess or a very unsure one, then four reasons are provided. There are eight possible reasons for problems in interpretation. These are all described in the Handbook.

After the degree of uncertainty has been entered, the interpreter then enters other descriptive information about the target.

Each frame of film can have several targets. All frames of film within a single flight line will have the exact same set of flight line information. All the targets within one frame will have identical ground control points. The set of flight line information and the ground control points need not be entered into the data record more than once. The appropriate set of flight line information and the appropriate set of ground control points are automatically written into the disk file in their proper location.

Before the targets are analyzed on the film, the flight line information for the roll of film being analyzed is stored in memory. When the ground control points for a frame of film are first digitized, that data is also held in memory. Target information, when encoded, is written to the memory along with flight line data and control point data. If another target in the same frame is the next point to be digitized, the set of flight line data is not erased, nor is the control point information.

When a new frame or a new flight line is interpreted, the memory locations for these sets of information must be changed appropriately.

Ground Control Points

A set of four ground control points are selected within each frame. The latitude and longitude of these points can be determined from the USGS quad map. Four points that can be located on the map are also selected from the imagery. The location of these points are marked and labeled on a mylar sheet overlain on the quad map. Steps are taken to register the mylar sheet to the quad map so the ground control points marked on the mylar sheet can be located again. The four points are also digitized and their XY coordinate values stored in the target record (physical record 2). For a more complete discussion, refer to the variable description under control points in the Handbook.

All the targets within the same frame will have the same identical set of control points. Thus, for each frame they are only identified once. The data entry software will automatically assign this set of control points to every target digitized within the frame. When the operator goes to another frame, another set of control points must be identified and digitized.

Writing Records Into Storage

For each target record there are four physical records (cards). This data is written and stored on a magnetic disk. A console with the two disk drives is connected to the ORION terminal. As soon as a disk of data is full of records (31 targets), the file containing the target records is copied to two backup disks.

Text Editor

Before files are transferred to the backup disks, any records that need corrections are edited with the program titled EDIT60R7.COM if necessary. This operation was rarely used as the interpreter could correct records while encoding.

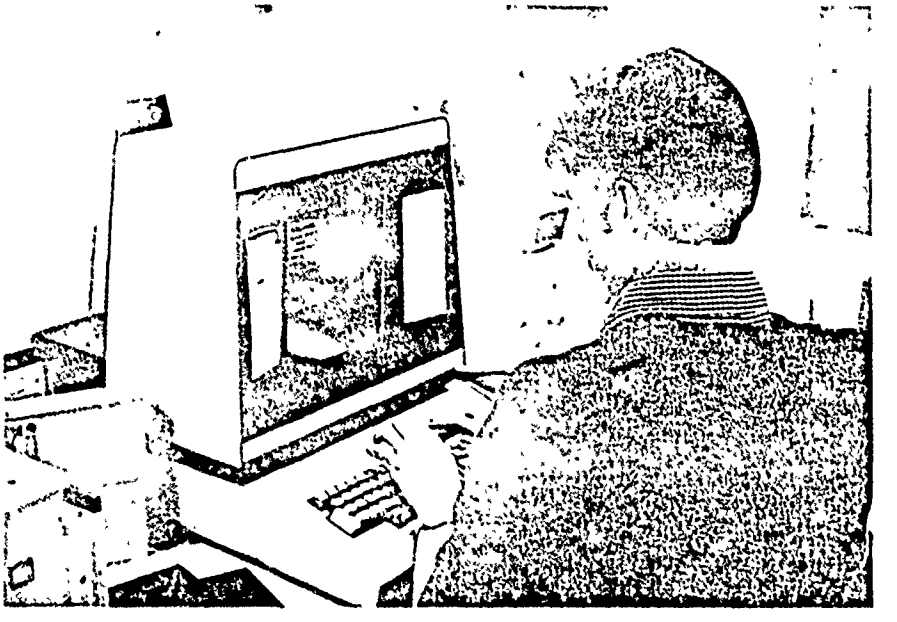
An interactive text editor is used to correct any mistakes in the data records. It can be used to correct errors in the flight line file (FORTØ6.DAT) or in the target record file (FORTØ7.DAT). The text editor is designed to prevent as much as possible additional mistakes caused by the record correcting process. The operator must provide to the edit program the exact position and the incorrect characters in the data record. After this is done properly the operator can provide to the edit program the correct characters. It was not a standard practice to scan the records for errors. The interpreter usually knew when mistakes were made during the encoding process. Thus, scanning of all records was unnecessary.

Display Program

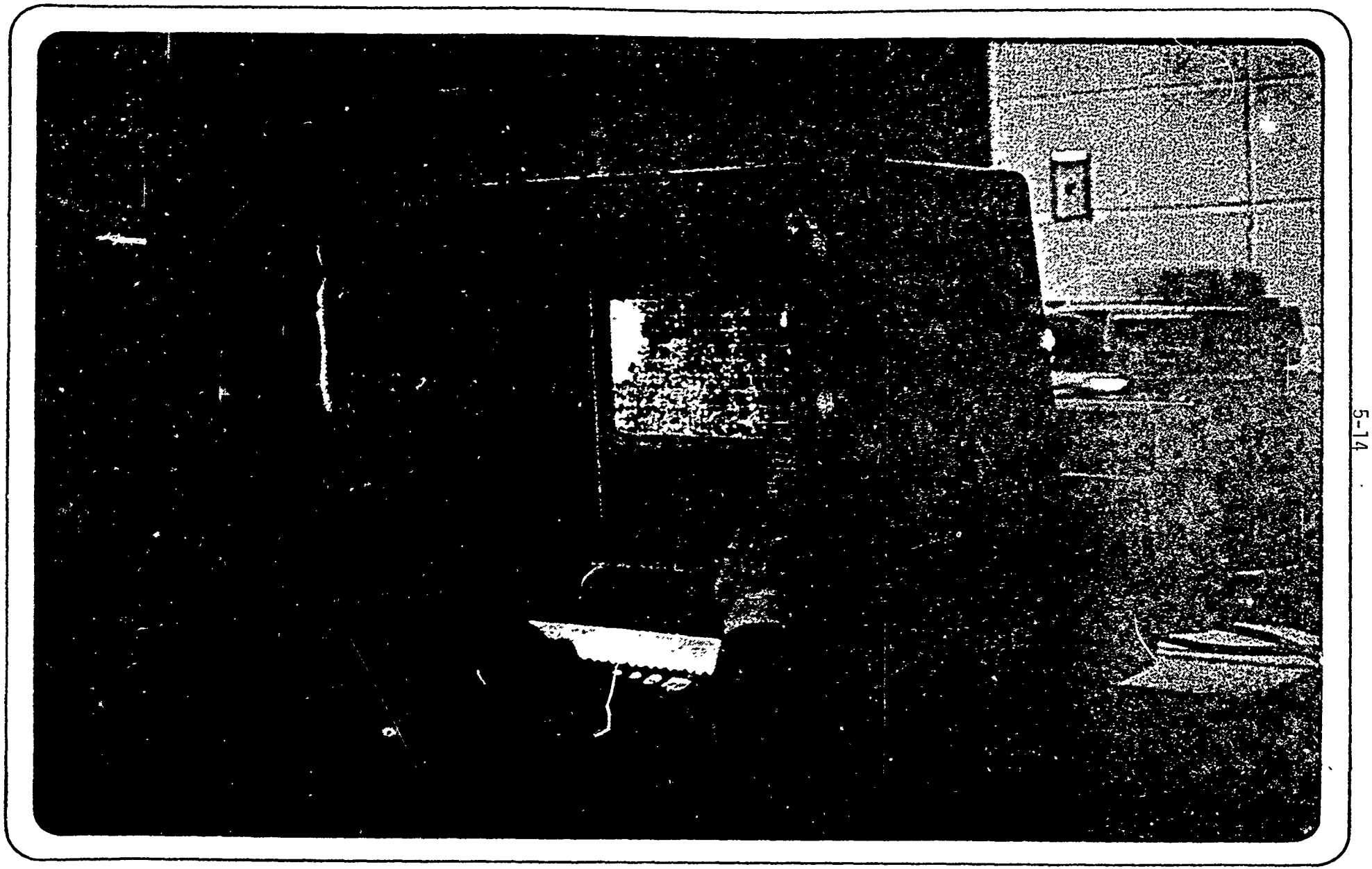
A program that displays individual flight line records (1 physical record) and target records (4 physical records) was used. Displaying individual records is important for three reasons: 1) the individual records can be scanned for correctness, 2) the display capability makes sure values are written in the proper columns within the record, and 3) locally accessible information retrieval system which can also be analyzed.



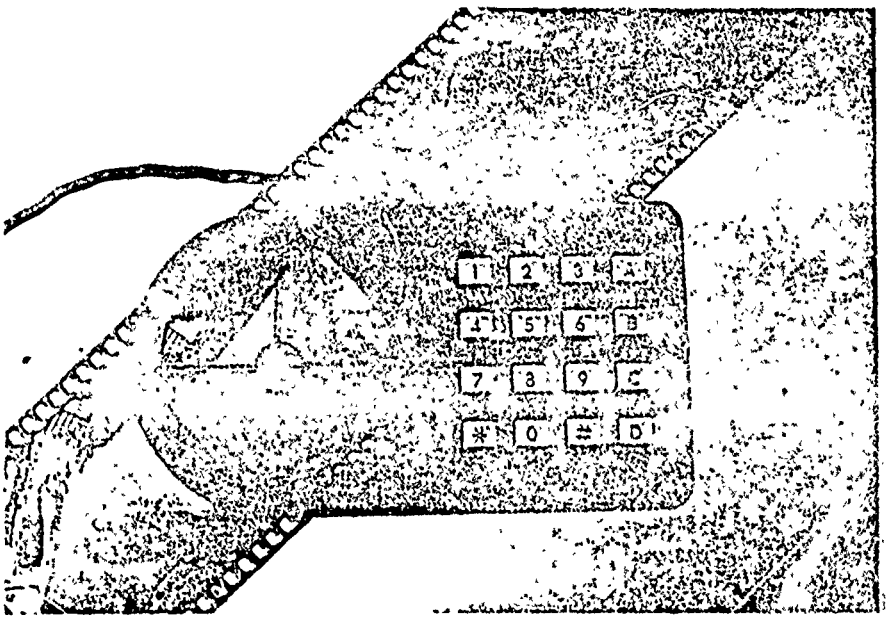
Photograph 5-1. Interpreting and Digitizing Targets.



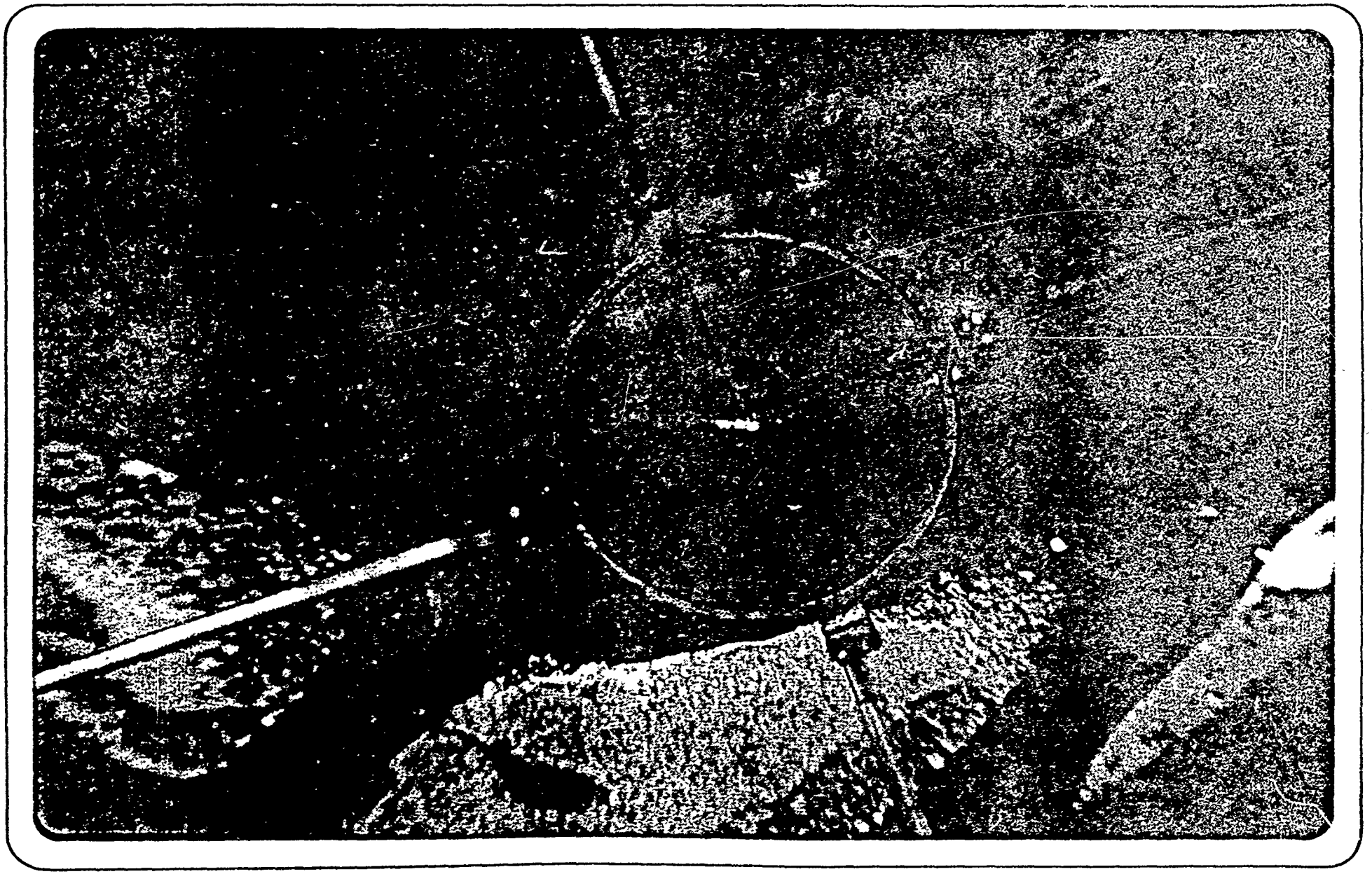
Photograph 5-2. Magnavox Orion Graphics Terminal in Use.



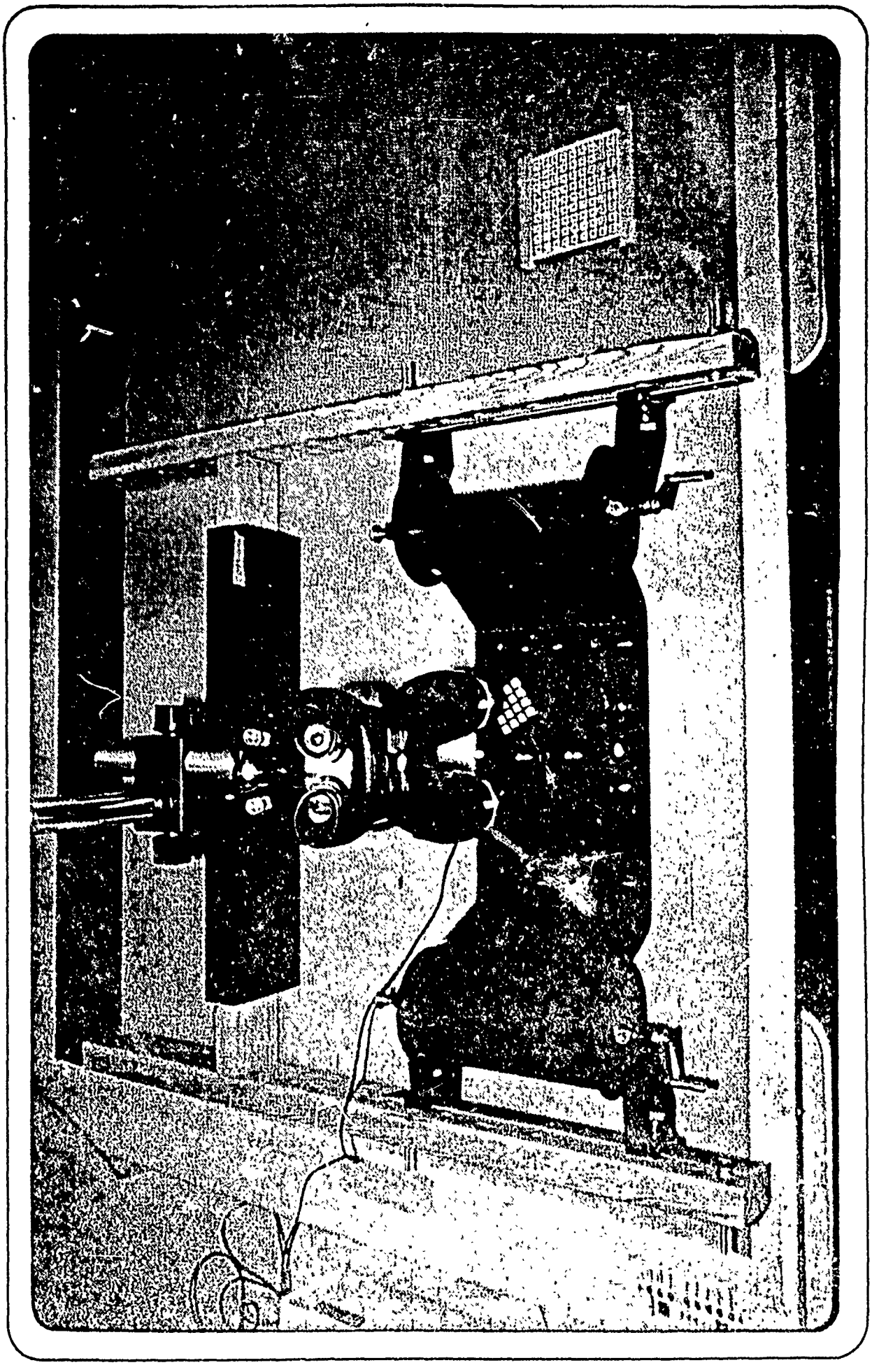
Photograph 5-3. Magnavox ORION Graphics Terminal

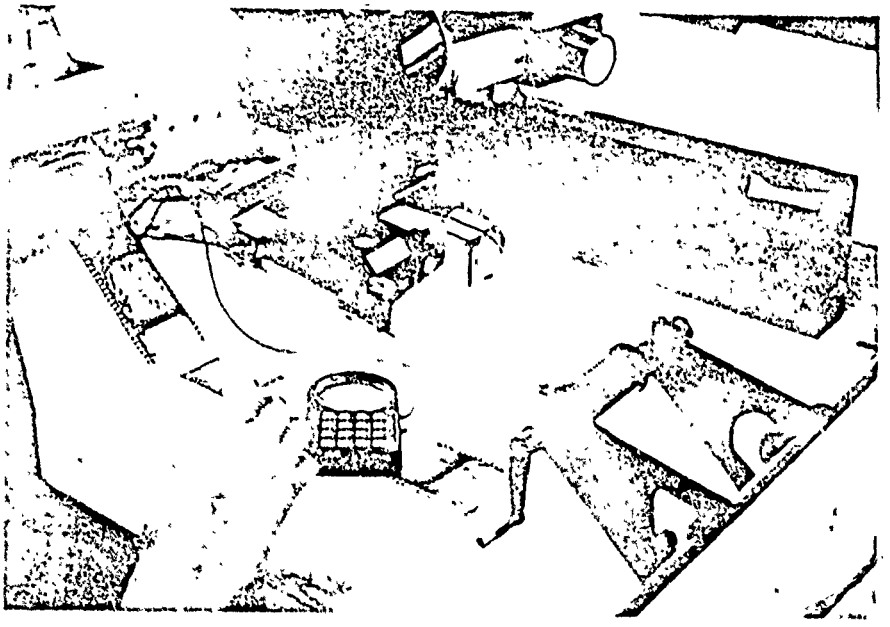


Photograph 5-4. Digitizing Cursor Positioned on Film.

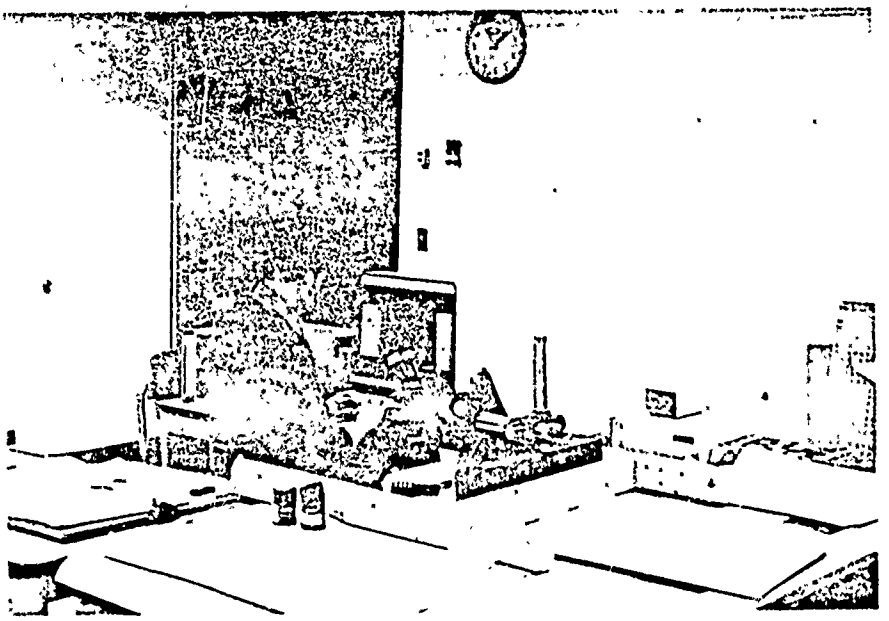


Photograph 5-5. Close-up of Digitizing Cursor Positioned on Film





Photograph 5-7. Film Winders and Digitizing Cursor (close-up).



Photograph 5-8. Workspace for Film Interpretation and Data Encoding.

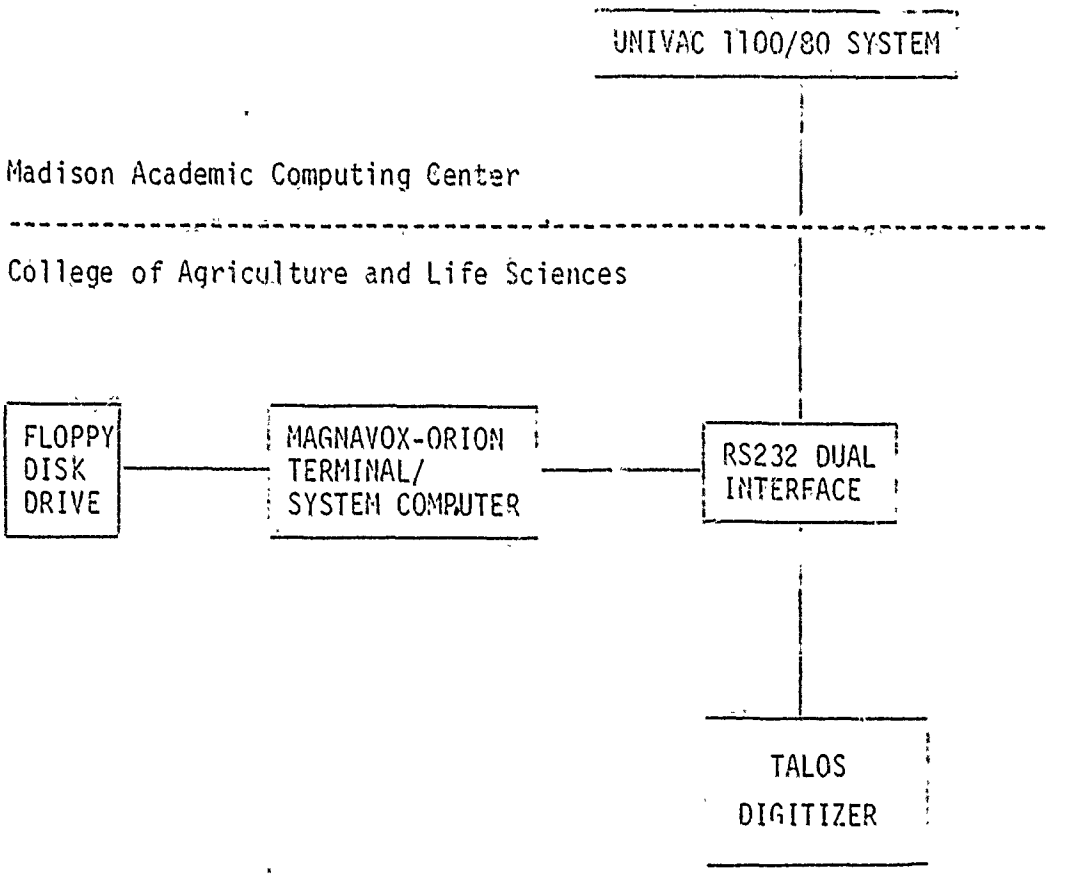


Figure 5-1. Hardware Configuration

APPENDIX 5.A. ORION/TALOS SOFTWARE

This appendix contains six figures of the functional organization of the software developed to support aerial photography processing using the ORION system and TALOS digitizer and to transmit collected data to the UNIVAC 1100/80 system for statistical analysis. It also includes a summary description of how the software/operator interact and function. Listings of the software are included in Book 8. Altogether the software represents somewhat less than 2500 lines of source code and somewhat less than 270 hours of development time. The reader is cautioned that the development time may be very much understated as the software was developed by very experienced and knowledgeable staff.

The first diagram presented depicts the software used to encode flight line data and is collectively referred to as the ENTER program. Second is BDIGITIZ, which is the name for the software used to encode data about the targets. ED60R7 is the name given to the software used to edit known errors. The two programs QREAD and QREAD7 are display programs for the flight line and target data bases. They can quickly retrieve and display information collected about any flight or any target. The final figure depicts the software used to transmit data to the UNIVAC 1100/80 from the ORION.

In Figure 5.A.1 the main software module ENTER first calls ORWFIL to open or re-open the Flight Line Data Base for data enetry. ENTER then proceeds to prompt the operator as to which field value should be entered next and what values are legitimate. It uses IVTYP, ILTYP and ITYP to verify that a legitimate value for the field has been entered. In this program and in general the operator's entry is validated and if not legitimate, he is requested to re-enter a correct value.

In Figure 5.A.2 BDIGITIZ calls FLINEM. This subroutine retrieves data from the Flight Line Data Base corresponding to the film roll currently being processed. ORWFIL, ITYP, ILTYP and IVTYP are used as in the ENTER program. CTPT supervises obtaining the control points from the film frame so that the data may later be relocated to a geo-reference system. BTPT supervises obtaining the XY location of the target and its classification.

The main module in Figure 5.A.3, ED60R7, handles operator interface for record request and calls ED128R to retrieve it. ED60R7 requires the operator to know the old contents of a field as well as its location before allowing any changes to be made.

Figures 5.A.4 and 5.A.5, respectively depict the software for retrieving and displaying records from the Flight Line and Target Data Bases. The various DSPLY modules are used according to the different record portions being displayed.

SENDMS in Figure 5.A.6 is the main module for soliciting from the operator which parts of the Target Data Base are to be transferred to the UNIVAC 1100/80. The WRLINE, ROLINE, and WASTE modules handle the communication protocol. The other modules verify transmission quality and reformat the data.

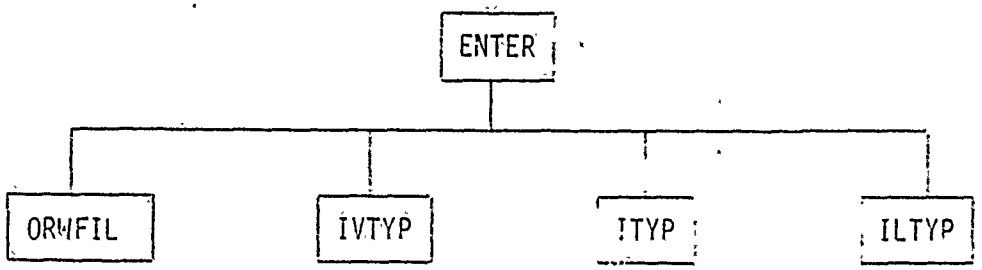


Figure 5.A.1. FLIGHT PROGRAM (Flight Line Encoding)

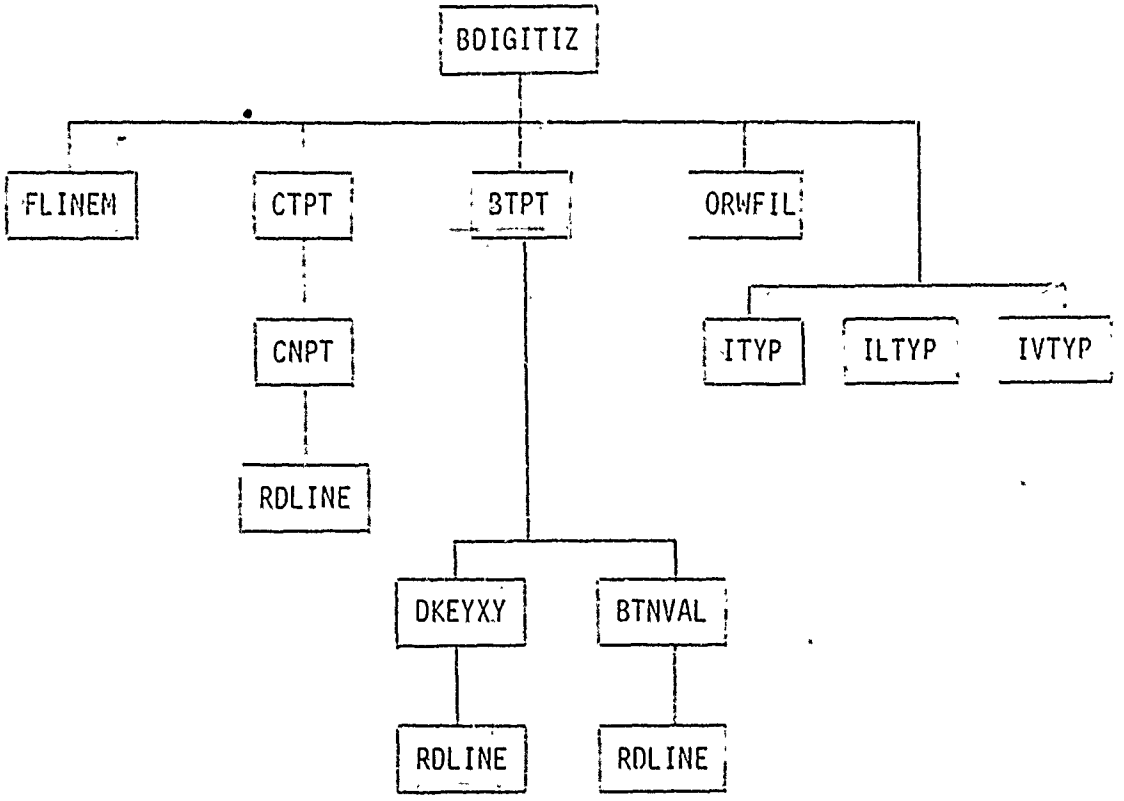


Figure 5.A.2. BDIGITIZ PROGRAM (Target Encoding)

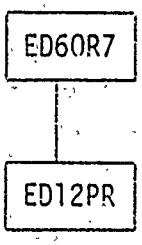


Figure 5.A.3. ED60R7 PROGRAM (Record Editing)

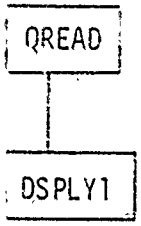


Figure 5.A.4. QREAD (Retrieve/Display Flight Line Data)

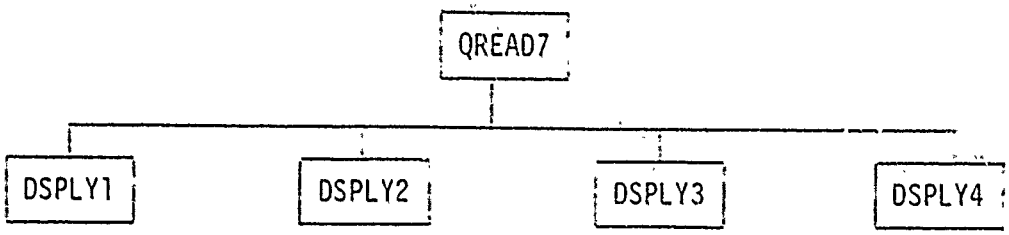


Figure 5.A.5. QREAD7 (Retrieve/Display Target Data)

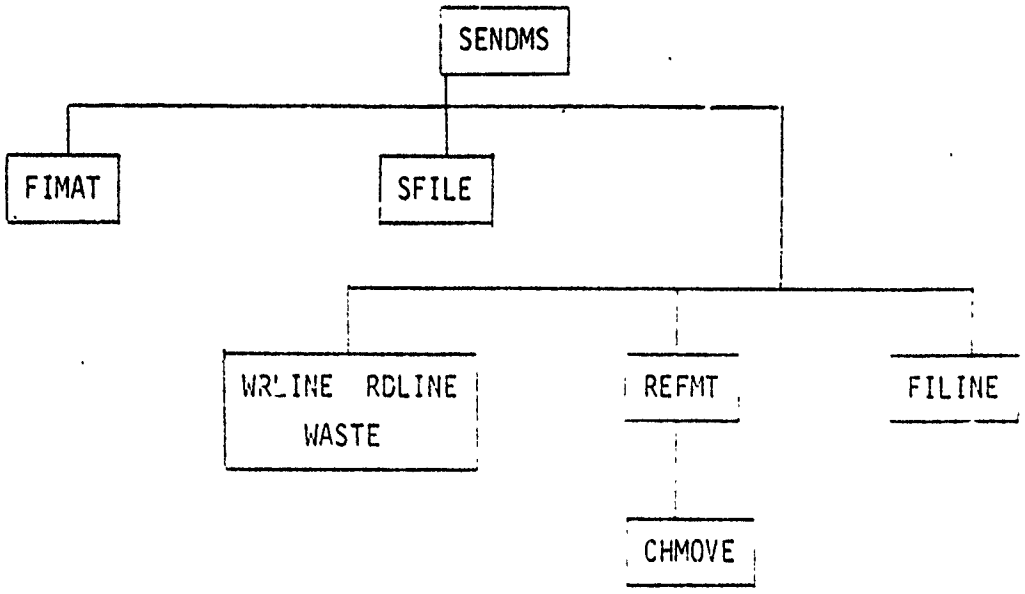


Figure 5.A.6. SENDMS (Data Transfer)

APPENDIX 5.B. DATA TRANSFER FROM THE ORION STAND-ALONG SYSTEM TO THE UNIVAC 1100/80 SYSTEM

During the data capture phase of the watercraft use survey, coded and digitized target data was stored on the ORION system floppy disk files named and formatted according to conventions described in the accompanying project handbook. The policy was to perform time-intensive data entry and editing chores in the dedicated off-line environment offered by the ORION stand-alone system.

For the purpose of analyzing large data sets however, the target data was reformatted to 80 column card image format and transferred to the UNIVAC 1100/80 system operated by the Madison Academic Computing Center. See figure 5.1 of the report for a schematic representation of this combined hardware configuration.

Establishing card image data transfer between the two computers had required the implementation of ORION software. This software was adapted in order to transfer the Mississippi target data. SENDMS, the resulting program, enabled the operator to set up a run which directed the transfer of any or all target data files from an ORION system floppy disk. Once the run was initiated, the operator was free to perform other tasks while casually monitoring the progress of the run. If an error or communication failure occurred, the operator was able to restart the run from a point at or near the point of failure and recover completely.

The typical data disk contained 16 files, each of which contained up to 32 target cases. For each disk to be transferred, one or more Data Transfer Logs was filled out (Fig. 5.B.1). These logs were used for organizing the data and counting the number of cases per flight. Based on these logs, a run file for each data disk was created on a master disk. These files were used to set up the data transfer runs, and were created and edited interactively.

The sequence of operations used for sending a file is as follows:

1) Create a run file on the master data transfer disk for the data disk using the ORION/CPM file editing processor.

2) Log on to the UNIVAC system using standard procedures, assign the output file, and equate it to USE name "PF".

3) Execute the SENDMS program on the master disk and load the run file for the data disk to be sent.

4) When the message "PAUSE NEWDSK - " appears on the terminal screen - remove the master disk from the disk drive, replace it with the data disk, and enter a return at the keyboard.

The SENDMS program will display the name of the file currently being transferred and the line number of each line as it is transferred. It will automatically transfer each file in the run file list. If problems arise due to system error or an error in specifying the run file, line numbers cease to be printed and an error message results. The operator must then intervene, usually by creating a new run file naming only those files not yet transferred. One serious type of error that can occur should be mentioned. This error occurs when the UNIVAC output file is not assigned with sufficient mass storage space in which to store the data. Under these circumstances, normal SENDMS operation will continue but the data will be lost.

See Figure 5.B.2 for a flow chart of SENDMS. The SENDMS code is listed in the computer printout Binder Book 8 filed with this report, along with examples of raw ORION data, UNIVAC data formatted for SPSS, and a run file example.

Setting up a disk for transfer typically required about 15 minutes. The actual transfer process required about 1 1/2 hours. There was an average of one abort per disk, usually caused by a communication line failure. These runs were restarted to complete the transfer.

Transferring the entire data set of 3673 cases required 16 3/4 hours. This is an average of 16.4 seconds per case. Insurance of data integrity was a contributing factor to data transfer speed. To insure data integrity, each line was echoed back to the ORION immediately after being transferred to the UNIVAC, and compared character for character against the original. This precaution cut in one-half the effective data transfer rate.

DATA TRANSFER LOG

miss79 / uw la dept / 3-3-80

(Please fill one of these out for each flight per disk.)

Disk pair MISS79(16)-3A/B Flight date July 4 185

Data entry by Andy M. Date ready 3/5/80 Remarks

Transferred by Greg M Date 3/8/80 Remarks 1 of 2 files this disk

	Filename	Cases		Filename	Cases
1	F070A.DAT	32	11		
2	B	32	12		
3	C	3	13		
4	F071A.DAT	32	14		
5	B	30	15		
6	C	32	16		
7	D	13	17		
8	F072A.DAT	6	18		
9			19		
10			20		

Figure 5.B.1. An Example of a Data Transfer Log.

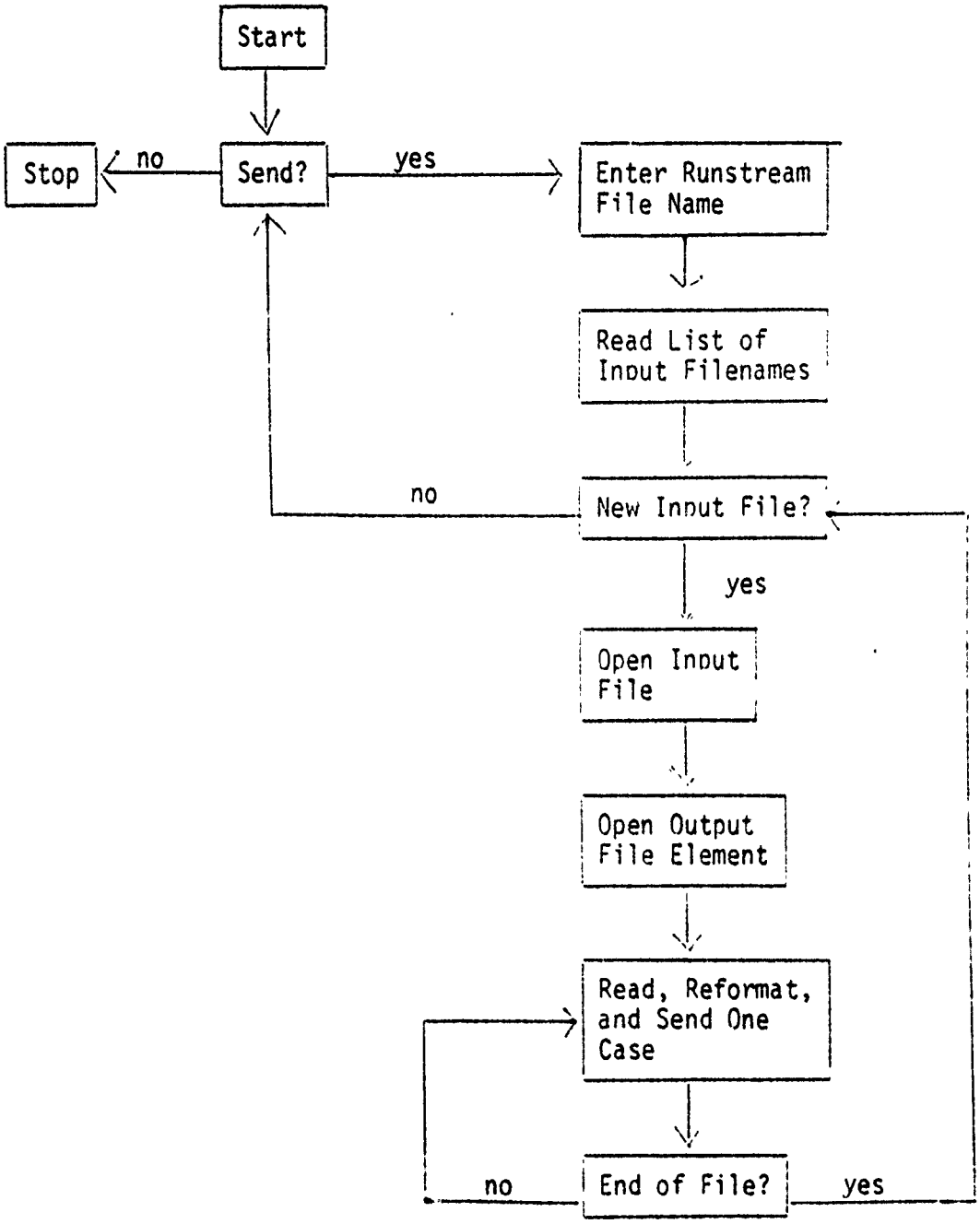


Figure 5.B.2. SENDMS Program Flow Chart.

APPENDIX 5.C. MANAGEMENT AND USE OF THE DATA ON THE UNIVAC 1100/80 SYSTEM

The data files transferred from the ORION were stored as elements in a single UNIVAC system program file. After transfer was completed, these elements were aggregated to form six large elements, one for each of the six flight dates. There were a total of 3673 cases, with an average of about 600 cases per flight. Each case required five 80 column card images.

Statistical analysis based on this data was used to evaluate watercraft use patterns and the methodology. This analysis was in the form of frequency tables and cross-tabulations performed using the statistical package SPSS (Statistical Package for the Social Sciences - Version 8).

All computer graphics in the report were produced with the SHOW processor, an interactive graphics program available at the Madison Academic Computing Center. The bar graphs and line graphs are based on the SPSS statistical output. The two-dimensional point graphs are plots of the actual digitized target coordinates. For this application, UDH (Unified Data Handler), also available at the Madison Academic Computing Center, was first used to sort the data by such factors as target type and activity status.

SECTION 6.

AERIAL PHOTOGRAPHIC INTERPRETATION HANDBOOK

AERIAL PHOTOGRAPHIC INTERPRETATION HANDBOOK

The handbook includes a description of the way each variable is measured, interpreted, and encoded. The variables are organized into two groups: flight line variables and target variables. Flight line variables are: TEAMI, POOL, YEAR, DATE, DAYWK, EVENTS, MINSTG, FLDSTG, UPSTG, DWNSTG, FLMLOT, FLMSEQ, FILM, NEXROL, HPRIME, TILT, ORIENT, REVERS, FOCAL, ENDLAP, CLDVAR, CLDCOD HAZE, TURB, CLDCOV, INCLEM, FLINE, NEXLIN, FLAX, FLSTRT, DELTAT, CRAB, EXPOSR, and LINK. The flight line variables are encoded using the ENTER program. The target variables include: ROLSEQ, NOQUADS, QD1, QD2, QD3, QD4, CP1X, CP1Y, CP2X, CP2Y, CP3X, CP3Y, CP4X, CP4Y, TARGET, TARCOX, TARCOY, BCHDEV, BCHCOV, SHORE, NOBRGS, DECOYS, CHANEL, ACTIV, MODUSE, SKIERS, and DIRXTN. Target variables are encoded using the BDIGITIZ program. The use of both the ENTER and BDIGITIZ program are explained on the following pages.

The ENTER Program

The ENTER program is used to encode the flight line data variables. The flight line variables are: TEAMI, LINK, POOL, YEAR, DATE, DAYWK, EVENTS, MINSTG, FLDSTG, UPSTG, DWNSTG, FLMLOT, FLMSEQ, FILM, NEXROL, HPRIME, TILT, ORIENT, REVERS, FOCAL, ENDLAP, CLDVAR, CLDCOD, HAZE, TURB, CLDCOV, INCLEM, FLINE, NEXLIN, FLAX, FLSTRT, DELTAT, CRAB, and EXPOSR.

Listed below is the set of steps used to operate the ENTER program:

1) Turn ORION on. Load operating system.

2) Insert the program disk into disk drive A.

3) Insert data disk into disk drive B.

4) Check film log book. Make sure the flight lines to be encoded have been numbered with a unique, three digit link number.

5) Key ENTER.

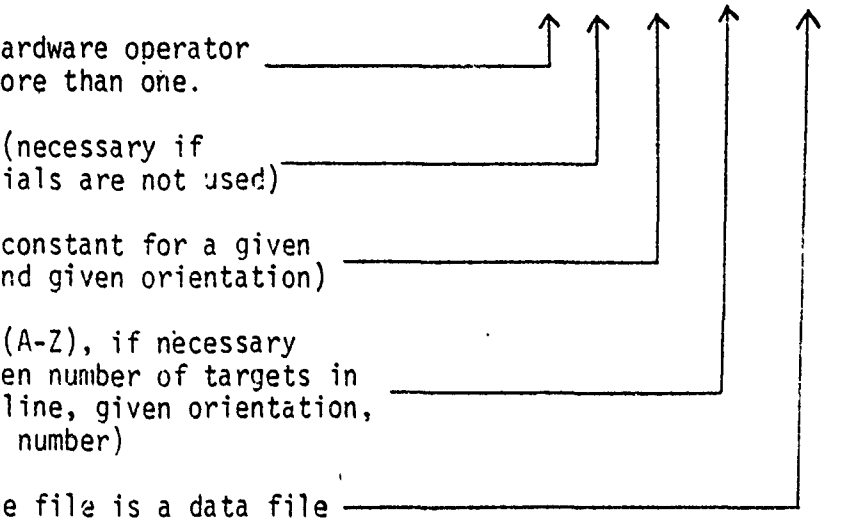
6) Encode values for variables according to the messages that appear on the terminal screen.

7) After a flight line is encoded, the ENTER program will prompt the encoder to either stop the encoding session or encode another flight line.

8) When all of the flight lines for one session have been encoded, the ENTER program is exited. The flight line records will have been stored in a file named FORTØ6.DAT. It is best to store the flight line records in a series of data files. The ENTER program can write data into a file names FORTØ6.DAT. Thus, FORTØ6.DAT, after it is full (100 records), must be changed to FORTØ6A.DAT. This means additional flight line records can be written into an empty FORTØ6.DAT and the previously encoded flight line records exist in FORTØ6A.DAT.

9) When targets are interpreted and their information is encoded, the file containing the relevant flight line information must be changed from FORTØ6A.DAT, for example, to FORTØ6.DAT. The BDIGITIZE program can access flight line data in a file named FORTØ6.DAT.

1. The file name syntax: KFF123B.DAT (exploded: KF F 123 B. DAT)



2. Initials of hardware operator encoder, if more than one.
3. Alpha prefix (necessary if operator initials are not used)
4. Link number (constant for a given flight line and given orientation)
5. Alpha suffix (A-Z), if necessary (necessary when number of targets in given flight line, given orientation, exceeds 32 in number)
6. Indication the file is a data file

11) Each file of target records is backed up on data disk A and data disk B. The file name is changed from FORTØ6.DAT to a file name like that above through the copy processor PIP (Peripheral Interchange Processor). After the FORTØ7.DAT has been copied on the data disk, it can be erased on the program disk. A new set of targets can now be inserted into a now empty FORTØ7.DAT.

The BDIGITIZ Program

For the target variables described in the handbook, the BDIGITIZ program is used to encode information. The procedures for using the BDIGITIZ program to enter ground control points, and encode target information are discussed below.

1) Turn ORION on.

2) Insert program disk into disk drive A.

3) Insert data disk A into disk drive B.

4) Key in control "C" for both disk drive A and B.

5) Key in "5 x 7" from the program disk. This will execute a program which decreases the print size.

6) Before the data entry can begin the following things must be done.

   A) Film must be properly inserted in the rollers. The plexiglass cover must be positioned over the film.
   B) The zoom stereoscope must be adjusted properly for viewing.
   C) The light source for the digitizing surface must be turned on.
   D) The digitizing control unit must be turned on. The cursor must be attached to the digitizing control unit. The digitizing control unit must be reset.
   E) The appropriate quad map must be selected and a mylar sheet overlay registered to it.

7) The operator enters BDIGITIZ on the keyboard.

8) The operator enters the link number (see handbook) of the flight line being interpreted. This will call up the appropriate flight line record from FORTØ6.DAT, which will be programmatically associated with the target data record.

9) As the messages indicate the operator encodes values from the keyboard or digitizes points on the film image with the cursor. Refer to the handbook for an explanation of the use of the cursor in digitizing control points and targets.

10) The BDIGITIZ program inserts data into a file called FORTØ7.DAT. This file can hold only 31 records or targets. When 31 targets have been entered, the program must be exited. The contents of the FORTØ7.DAT program are copied into a file on data disk A and data disk B. This file is named according to a set of rules given below.

OPERATOR/OPERATOR TEAM NUMBER TEAMI

File Specification	Field width	Card No.	Column No.
Original file	2	1	3-4
SPSS file	2	1	20-21

Possible values:

Andy Morton and Ken Foyil	01
Andy Morton and Lyonel Wisnewski	02
Ken Foyil and Lyonel Wisnewski	03
Lyonel Wisnewski	04
Andy Morton	05
Ken Foyil	06

An individual or a two-person team performs the encoding of redundant data. Originally, the two-person team encoded data, but during most of the project only one person encoded data at each data entry session. Errors in encoding were discovered to amount to less than 1%. Although reliability might be improved slightly using the two-person (team) concept, that must be weighed against the additional (essentially double) man-hours required for encoding. The same concept was used in the target digitizing process. When problems with control point digitization were encountered, a 99 value was encoded in TEAMI.

POOL NUMBER IDENTIFICATION POOL

File Specification	Field width	Card No.	Column No.
Original file	2	1	5-6
SPSS file	2	1	22-23

Possible values: 11-22

Null values: unknown -8

Pool "i" refers to that river segment immediately behind (upstream) Lock and Dam "i".

DATE OF IMAGERY - YEAR YEAR

File Specification	Field width	Card No.	Column No.
Original file	2	1	7-8
SPSS file	2	1	24-25

Possible values: 01-99

Null values: unknown -8

This variable is first in a sequence of four (see also DATE, DAYWK, and EVENTS) used to characterize the date the imagery was obtained.

DATE OF IMAGERY - SEQUENTIAL DAY OF YEAR DATE

File Specification	Field width	Card No.	Column No.
Original file	3	1	9-11
SPSS file	3	1	26-28

Possible values: 001-366

Null values: unknown -08

This variable's value is used to form part of the program file element name for the SPSS files. See also YEAR, DAYWK, and EVENTS.

DATE OF IMAGERY - DAY OF WEEK DAYWK

File Specification	Field width	Card No.	Column No.
Original file	2	1	12-13
SPSS file	2	1	29-30

Possible values:

Monday	01
Tuesday	02
Wednesday	03
Thursday	04
Friday	05
Saturday	06
Sunday	07

Null values: unknown -8

See also YEAR, DATE, and EVENTS.

DATE OF IMAGERY - COINCIDENCE OF SPECIAL EVENTS EVENTS

File Specification	Field width	Card No.	Column No.
Original file	2	1	14-15
SPSS file	2	1	31-32

Possible values:

No known coincidence of special events	00
Memorial Day weekend, but not Memorial Day	01
Memorial Day (Holiday)	02
July 4th (Holiday)	03
Labor Day weekend, but not Labor Day	04
Labor Day (Holiday)	05

Null values: unknown -8

For the purposes of the project, only the above listed special events were appropriate, but up to 99 such events can be enumerated. This variable can be used to code non-representative or unusual days or situations. See also YEAR, DATE, and DAYWK.

POOL STAGE - MINIMUM WATER SURFACE ELEVATION MINSTG

File Specification	Field width	Card No.	Column No.
Original file	4	1	16-19
SPSS file	4	1	33-36

Possible values: (x 10) in feet above MSL

Pool 11	6030
Pool 12	5920
Pool 13	5830
Pool 14	5720
Pool 15	5572
Pool 16	5435
Pool 17	5360
Pool 18	5280
Pool 19	5182
Pool 20	4755
Pool 21	4700
Pool 22	4595

Null values: unknown -008

The values shown above represent the minimum stage multiplied by a factor of 10, so that the variable can be represented as an integer. Stage values were extracted from the "Daily Hydrological Bulletin," Rock Island District, U.S. Army Corps of Engineers. This scaling factor is carried through on the other three stage variables: FLDSTG, UPSTG, and DWNSTG. Pool stage stratification, through selective use of the four river stage variables, can allow examination of seasonal aspects, related to pool depth and discharge, of pool use.

POOL STAGE - FLOOD STAGE ELEVATION UPSTREAM END FLDSTG

File Specification	Field width	Card No.	Column No.
Original file	4	1	20-23
SPSS file	4	1	37-40

Possible values: (x 10) in feet above MSL

Pool 11	6150
Pool 12	6042
Pool 13	5972
Pool 14	5827
Pool 15	5681
Pool 16	5575
Pool 17	5486
Pool 18	5397
Pool 19	5265
Pool 20	4938
Pool 21	4825
Pool 22	4708

Null values: unknown -008

The values shown above represent the flood stage elevations scaled by a factor of ten. Refer to narrative for MINSTG for additional discussion.

POOL STAGE - ACTUAL SURFACE ELEVATION UPSTREAM END UPSTG

File Specification	Field width	Card No.	Column No.
Original file	4	1	24-27
SPSS file	4	1	41-44

Possible values: (x 10) in feet above MSL

	Value Range (min)	(max)
Pool 11	6030	6270
Pool 12	5920	6162
Pool 13	5830	6092
Pool 14	5720	5947
Pool 15	5572	5801
Pool 16	5435	5695
Pool 17	5360	5606
Pool 18	5280	5517
Pool 19	5182	5385
Pool 20	4755	5058
Pool 21	4700	4945
Pool 22	4595	4828

Null values: unknown -008

The values shown above represent the range of daily river stage at the upstream end of the indicated pool scaled by a factor of ten. Note that the value range is the same as for the variable DWNSTG, with the constraint that UPSTG DWNSTG (actual value) for any given pool on a given day. Refer to narrative for MINSTG for additional discussion.

POOL STAGE - ACTUAL SURFACE ELEVATION DOWNSTREAM END DWNSTG

File Specification	Field width	Card No.	Column No.
Original file	4	1	29-32
SPSS file	4	1	45-48

Possible values: (x 10) in feet above MSL

	Value Range (min)	(max)
Pool 11	6030	6270
Pool 12	5920	6162
Pool 13	5830	6092
Pool 14	5720	5947
Pool 15	5572	5801
Pool 16	5435	5695
Pool 17	5360	5606
Pool 18	5280	5517
Pool 19	5182	5385
Pool 20	4755	5058
Pool 21	4700	4945
Pool 22	4595	4828

Null values: Unknown -008

The values shown above represent the range of daily river stage at the upstream end of the indicated pool scaled by a factor of ten. Note that the range of values is the same as for the variable UPSTG, with the constrating that UPSTG DWNSTG (actual value for any given pool on a given day). Refer to narrative for MINSTG for additional discussion.

PROCESSED FILM ROLL LOT NUMBER FLMLOT

File Specification	Field width	Card No.	Column No.
Original file	2	1	33-34
SPSS file	2	1	49-50

Possible values: 01-99

Null values: not applicable -9
unknown -8

For the purpose of this project, the first two digits of the processing laboratory's control number were coded as the film roll lot number (70mm film only). The last three digits became the film roll sequence number (see FLMSEQ). The Fortran compiler for the ORION microcomputer precluded using integer values greater than 32,767 (i.e., $2^{15} - 1$), and since all the processing lab's control numbers were greater than that value, the above cited strategy was chosen. An alternative strategy (recommended for longer term operational work) is to use the last two digits of the current year (see YEAR) as the value to be given to FLMLOT, and a unique, locally managed sequential numbering system for the variable FLMSEQ. This should be done instead of relying on the processing laboratory's numbering system, which may have no chronological significance. FLMLOT is used twice: when encoding the redundant data at the terminal and again when accessing and retrieving that redundant data record during the target digitizing process. This redundant data record access and retrieval process also requires the use of three other variables, LINK, FLINE, and FLMSEQ. It is important that the combination of FLMLOT and FLMSEQ be unique for each roll of film, otherwise the redundant data record access and retrieval becomes ambiguous, resulting in improper matching of redundant data with the imagery being interpreted. Since the 9" x 9" imagery (one large roll) was received with no processor number attached to it, the FLMLOT and FLMSEQ values attached to it locally were 01 and 001, respectively.

PROCESSED FILM ROLL SEQUENCE NUMBER FLMSEQ

File Specification	Field width	Card No.	Column No.
Original file	3	1	35-37
SPSS file	3	1	51-53

Possible values: 001-999

Null values: unknown -08
not applicable -09

For the purpose of this project, the last three digits of the processing lab's control number were coded as the film roll sequence number, the first two as the film roll lot number (see FLMLOT). For discussion of this numbering strategy, an alternative strategy, the importance of a unique FLMLOT/FLMSEQ combination, and use of FLMSEQ elsewhere, refer to the narrative for FLMLOT.

FILM/FILTER COMBINATION USED FILM

File Specification	Field width	Card No.	Column No.
Original file	2	1	38-39
SPSS file	2	1	54-55

Possible values:

70mm x 15' color infrared transparency (Kodak Type 2443) with #12 yellow filter	01
70mm x 15' true-color transparency (Kodak Type 2448) with haze filter	02
9" x 9" color-infrared transparency with #12 yellow filter	03

Null values: unknown -8

The values cited above are not exhaustive, but were the only three film types used for this project. The field width allowed should easily accommodate other combinations beyond those cited. The variable can be used to analyse the effects of film type on the ability to interpret targets.

NUMBER OF EXPOSURES IN ROLL OF FILM UNDER EXAMINATION NEXROL

File Specification	Field width	Card No.	Column No.
Original file	3	1	40-42
SPSS file	3	1	56-58

Possible values: 001-070 (for a 15' roll of 70mm film)
001-999 (otherwise)

Null values: unknown -08

This variable indicates the actual number of exposures (at the operational flight altitude), exclusive of those exposures at the leading end of the roll required to attain spool tension for film advancing in the film magazine, and those at the trailing end of roll taken under non-operational (i.e., unplanned) conditions, for the roll of film under examination. In the case of the 15' rolls of 70mm film, the maximum number of exposures is approximately 70. The maximum will vary with the type of film and magazine/camera combinations used. The 3 character field width should accommodate practical bulk load magazine capacities. NEXROL is used as the maximum value for the variables NEXLIN and ROLSEQ. Although not incorporated into the existing data entry software, the maximum value can be adjusted to accommodate film with a greater number of exposures.

NOMINAL FLIGHT ALTITUDE ABOVE MEAN TERRAIN HPRIME

File Specification	Field width	Card No.	Column No.
Original file	5	1	45-49
SPSS file	5	1	59-63

Possible values: 00300-32767 (expressed in feet)

Null values: unknown -8

The practical upper limit for 9" x 9" aerial photography should be well below 32,667 feet AMT (32,767 being the maximum integer value useable on the ORION). It could vary enough so that the compiler integer value limitation is used as the upper limit for the variable. 300' AMT was felt to be as low an altitude as could be flown with second-interval (re: DELTAT) intervalometers and wide angle lenses for 70mm format film and minimal endlap (see FOCAL and ENDLAP). This variable can also be used to analyze the effects of flight altitude on the interpretation used to analyze various targets.

NOMINAL ANGLE OF CAMERA TILT TILT

File Specification	Field width	Card No.	Column No.
Original file	2	1	50-51
SPSS file	2	1	64-65

Possible values: 00-25 degrees
(vertical orientation = 00 degrees)

Null values: unknown -8

Twenty-five degrees of tilt was the maximum tilt designed into the two-camera mount for the project. A tilt of 19 degrees was used for all oblique aerial photography, since that was the maximum practical angle in an operational configuration, i.e., in the Cessna 180 aircraft rented. Other aircraft with varying belly hole configurations will allow varying degrees of tilt, but 25 degrees approaches a practical maximum. The tilt angle is a necessary element in approximating exterior orientation parameters in photogrammetric adjustments.

CAMERA ORIENTATION TO PLANNED FLIGHT LINE VECTOR ORIENT

File Specification	Field width	Card No.	Column No.
Original file	2	1	52-53
SPSS file	2	1	66-67

Possible values: FLL (flight line left) 01
FLR (flight line right) 02

Null values: unknown -8
not applicable (vertical photography) -9

This variable is applicable only to two-camera oblique photography. The two camera oblique system requires each camera to have a fixed orientation to the flight line (see FLAX). The orientation is termed either flight line left (FLL) or flight line right (FLR), as viewed from above, to the flight line. A value of -9 (not applicable) is encoded for all planned vertical photography. This variable can also be used to distinguish between exposures, or frames, in the FLL and FLR film rolls when conducting cross-categorical analyses, including targeting reliability tests. Even when flight lines are flown "backwards", i.e., in the opposite direction, from that originally planned (see REVERS), the value for ORIENT remains the same as the "planned" orientation. This contingency is reflected in the value for the variable REVERS.

REVERSAL CONTINGENCY IN "AS FLOWN" FLIGHT LINE DIRECTION REVERS

File Specification	Field width	Card No.	Column No.
Original file	2	1	54-55
SPSS file	2	1	68-69

Possible values:

Normal execution as planned	00
Flight line flown in reverse sequence/direction	01

Null values:

unknown	-8
not applicable (vertical photography)	-9

As a contingency measure, this variable reflects the situational reversal of flight direction from that originally planned for indicated flight lines. This allows the flexibility to continue a flight mission with only one camera when the second camera experiences malfunction or breakdown, and no backup camera is available. It should be noted that one camera orientation (see ORIENT) is flown in the planned direction and its companion orientation is flown in the opposite direction, i.e., 180° greater or less than that planned (see FLAX). It should also be noted that under this contingency condition that simultaneous lateral exposures (left and right) along the flight line, the normal condition for two-camera oblique photography, is precluded, and the possibility of multiple targeting of moving objects, i.e., boats, is very likely under this condition, much less so under normal conditions. Rolls of film exposed under this condition must be viewed, i.e., set up for targeting, as if they were of the opposite orientation as that indicated by the value for the variable ORIENT.

CAMERA LENS FOCAL LENGTH FOCAL

File Specification	Field width	Card No.	Column No.
Original file	2	1	56-57
SPSS file	2	2	20-21

Possible values: f = 40mm (70mm format) 01
f = 5 inches (9"x9" format) 02

Null values: unknown -8

This variable is necessary in photogrammetric adjustment computations and can also be used to differentiate between different lens focal lengths used with a given camera format.

NOMINAL ENDLAP (FORWARD OVERLAP) ALONG FLIGHT LINE ENDLAP

File Specification	Field width	Card No.	Column No.
Original file	2	1	58-59
SPSS file	2	2	22-23

Possible values: 10-60 degrees

Null values: unknown -8

Maximum endlap occurs with stereo photography, in which case the nominal endlap is usually 60 percent. Minimum endlap for planning purposes with any film format or flight altitude should be 10 percent. Adverse flight conditions such as significant head winds or tail winds can result in widely varying ground speeds and consequent gaps in areal ground coverage with minimal endlap, however. Twenty to twenty-five percent was an effective compromise used in this project's missions using two-camera oblique photography. The percent endlap is expressed along the flight line.

CLOUDINESS VARIABILITY CLDVAR

File Specification	Field width	Card No.	Column No.
Original file	2	1	60-61
SPSS file	2	2	24-25

Possible values: no variability (constant) 00
variability evident 01

Null values: unknown -8

The cloudiness variability, along with the dominant and variant cloud conditions (see CLDCOD and CLDCOV) serve to identify whether or not there is a significant enough difference in cloudiness over a given flight area to cause degradation of image quality (exposure) occasionally. The value for CLDCOV must be -9 (not applicable) if the value for CLDVAR is 00. Likewise, if CLDVAR is coded 01, then there must be a value in the range of 01 to 07 for CLDCOV, not equal to that for CLDCOD.

CLOUDINESS CONDITION - DOMINANT CLDCOD

File Specification	Field width	Card No.	Column No.
Original file	2	1	62-63
SPSS file	2	2	26-27

Possible values:

Clear	01
High scattered	02
Low scattered	03
High broken	04
Low broken	05
High overcast	06
Low overcast	07

Null values: unknown -8

This variable represents the cloudiness condition for which the camera exposure was set, for either constant or variable conditions. If recorded, there is always a value for this variable, regardless of variability of cloudiness. However, when CLDVAR = 01, then CLDCOD must not equal CLDCOV. The distinction between "high" and "low" cloud basis is visual and is expressed in terms relative to the flight altitude, "low" being either below, at or immediately above the flight altitude, and "high" being sufficiently high enough above the flight altitude so as to preclude the possibility of flying through the cloud cover. A low cloud basis does not necessarily imply that clouds will be present in the imagery. Scattered clouds represent approximately ten percent or less cloud cover, as measured by observing cloud shadows on the ground in the flight area. Overcast is essentially 100 per cent cloud cover, and broken clouds represent the range between scattered and overcast.

CLOUDINESS CONDITION - VARIANT CLDCOV

File Specification	Field width	Card No.	Column No.
Original file	2	1	64-65
SPSS file	2	2	28-29

Possible values:

Clear	01
High scattered	02
Low scattered	03
High broken	04
Low broken	05
High overcast	06
Low overcast	07

Null values: unknown -8
not applicable (no cloud variability) -9

This variable represents the cloudiness condition which in the opinion of the photographer was felt to be the variant condition, for which exposure was not set (see CLDCOD). If CLDVAR equals 00, CLDCOV must equal -9 (not applicable). If CLDVAR equals 01, then CLDCOV must take on a value in the range of 01 to 07, not equal to that for CLDCOD. Definition of terms (values) is identical to that for CLDCOD.

DEGREE OF HAZINESS HAZE

File Specification	Field width	Card No.	Column No.
Original file	2	1	66-67
SPSS file	2	2	30-31

Possible values: slightly hazy 01
moderately hazy 02
extremely hazy 03

Null values: unknown -8

In an aerial photographic context, there will always be at least a slight degree of haze (observed horizontally). Thus, there is not a "clear" value associated with this variable. The primary purpose of this variable is to indicate the difficulty in sighting along flight lines for the pilot. The possible values are defined as follows:

slightly hazy: at least five miles horizontal visibility and relative ease in sighting along flight lines.

moderately hazy: less than five miles horizontal visibility but no great difficulty in sighting along flight lines.

extremely hazy: very limited horizontal visibility and great difficulty in sighting along flight lines.

DEGREE OF TURBULENCE IN FLIGHT TURB

File Specification	Field width	Card No.	Column No.
Original file	2	1	68-69
SPSS file	2	2	32-33

Possible values: Light or no turbulence 01
Moderate turbulence 02
Severe turbulence 03

Null values: unknown -8

This variable is intended to indicate the likelihood of exposures with signficantly different tilt than planned due to turbulent tossing of the aircraft. The possible values are defined as follows:

Light or no turbulence: that condition in which the turbulence, if any, is too seldom encountered to be of any consequence in maintaining aircraft attitude.

Moderate turbulence: that condition in which the turbulence, when encountered, is frequent enough to cause frequent deviations in aircraft attitude, but does not significantly impair working conditions.

Severe turbulence: that condition in which the turbulence is almost constant, and of such magnitude as to make working conditions extremely difficult, if not intolerable, because of almost constant deviation in aircraft attitude.

THREAT OF INCLEMENT WEATHER INCLEM

File Specification	Field width	Card No.	Column No.
Original file	2	1	70-71
SPSS file	2	2	34-35

Possible values:

No threat of inclement weather in area	01
Threatening inclement weather in area	02
Inclement weather in progress over imaged area	03

Null values: unknown -8

This variable can be used in cross-categorical analyses to test for weather impact on river use.

FLIGHT LINE NUMBER FLINE

File Specification	Field width	Card No.	Column No.
Original file	2	1	93-94
SPSS file	2	2	36-37

Possible values: 01-99

Null values: unknown -8

This variable, for a given camera orientation (FLL or FLR, see ORIENT) provides sequential flight line numbers. However, since two cameras are used in the oblique photography, FLINE in and of itself does not provide a unique numbering system for redundant data record entry, access, and retrieval, hence the incorporation of the redundant data record link number (see LINK). FLINE, along with LINK, FLMLOT and FLMSEQ, is used in the redundant data record access and retrieval in the target digitizing process.

NUMBER OF EXPOSURES IN FLIGHT LINE UNDER EXAMINATION NEXLIN

File Specification	Field width	Card No.	Column No.
Original file	3	1	74-76
SPSS file	3	2	38-40

Possible values: 001-999 and NEXLIN must be less than or equal to NEXROL

Null values: unknown -8

This variable represents the number of exposures within the flight line (see FLINE) under examination. Two constraints are observed: NEXLIN must be less than or equal to NEXROL, and during the target digitizing process, the maximum number of values for the variable ROLSEQ, for a given flight line record (see LINK) equals NEXLIN.

PLANNED FLIGHT LINE BEARING (HEADING) FLAX

File Specification	Field width	Card No.	Column No.
Original file	3	1	77-79
SPSS file	3	2	41-43

Possible values: 000-359 (expressed in degrees)

Null values: unknown -08

Flight line bearing is measured in degrees clockwise from true north and is extracted from the photographic flight map. The value is used in first approximation of exterior orientation parameters in photogrammetric adjustment computations.

FLIGHT LINE START TIME (MILITARY/INTERNATIONAL SYSTEM) FLSTRT

File Specification	Field width	Card No.	Column No.
Original file	4	1	80-83
SPSS file	4	2	44-47

Possible values: 0700-1900

Null values: unknown -008

Flight line start time is expressed in terms of the military system. The limits indicated encompass what is felt to be times of day before which and after which the sun angle in midsummer (in the continental US northern tier of states) would be too low for reasonable aerial photography. It serves as an indication of the time of day during which the aerial photography was taken and can be used to analyze the impact of time of day on river use.

INTERVALOMETER TIME INTERVAL BETWEEN EXPOSURES DELTAT

File Specification	Field width	Card No.	Column No.
Original file	3	1	84-86
SPSS file	3	2	48-50

Possible values: 001-999 (expressed in seconds)

Null values: unknown -08

Time interval is expressed in seconds and can be expected to differ from one flight line to another in a given pool flight, especially if there are strong headwinds/tailwinds in which additional compensation for change in ground speed is required to maintain the planned endlap (see ENDLAP). It should be noted that some intervalometers have a capacity for intervals not exceeding 99 seconds. The above range should encompass all intervalometers.

DEGREE OF CRAB CORRECTION IN FLIGHT CRAB

File Specification	Field width	Card No.	Column No.
Original file	3	1	87-89
SPSS file	3	2	51-53

Possible values: -20 - 020 (expressed in degrees)

Null values: unknown -88

Crab is the condition arising when the camera mount is not aligned "true" to the actual (effective) direction of flight, noticeable usually when flying in a crosswind. Negative values indicate a counterclockwise compensating rotation of the camera mount, positive values a clockwise rotation, expressed in degrees. It should be noted that the unknown (null) value must be -88 (as opposed to -08) to be outside the range of possible values.

CAMERA EFFECTIVE EXPOSURE INDEX EXPOSR

File Specification	Field width	Card No.	Column No.
Original file	3	1	90-92
SPSS file	3	2	54-56

Possible values: (by sets of equivalent exposures)

1/125 @ f4	110
1/125 @ f4.7	115
1/250 @ f4, 1/125 @ f5.6	120
1/250 @ f4.7, 1/125 @ f6.6	125
1/500 @ f4, 1/250 @ f5.6, 1/125 @ f8	130
1/500 @ f4.7, 1/250 @ f6.6, 1/125 @ f9.3	135
1/500 @ f5.6, 1/250 @ f8, 1/125 @ f16	140
1/500 @ f6.6, 1/250 @ f9.3, 1/125 @ f13.2	145
1.500 @ f8, 1/250 @ f11, 1/125 @ f16	150

Null values: unknown -08

This index is applicable to the use of the Hasselblad 70mm camera system, but is adaptable to other systems. The actual index is scaled by a factor of ten to obtain the above integer values.

The f-stop/shutter speed combination can be varied to accommodate varying light conditions. Different settings are, in effect, equivalent in terms of total exposure. This index is a single value representing a set of equivalent settings. The index is that used with the Hasselblad 70mm EL/M 500 camera, Distagon 40mm lens system with which the 70mm photography was shot. An increase of one unit in the index (difference of ten in the scaled values) represents a two-fold reduction in total exposure (needed as the illumination intensity increases). Since the system increments this index in half-units (a result of half f-stop changes), the possible values are also incremented in half-units, as scaled by a factor of ten.

REDUNDANT DATA RECORD LINK NUMBER/DATA FILE NAME LINK

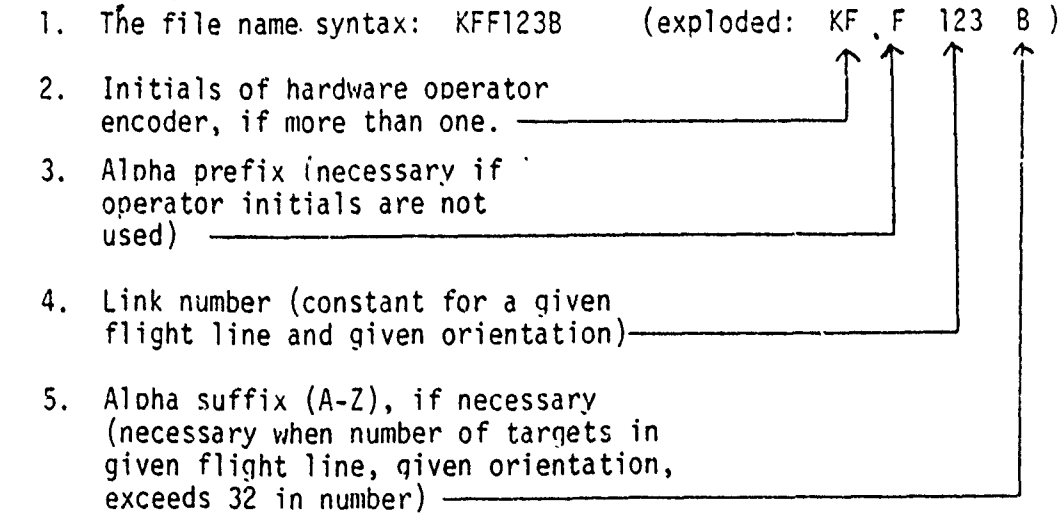
File Specification	Field width	Card No.	Column No.
Original file	3	4	65-67
SPSS file	N/A	N/A	N/A

Possible values: 001 - 999

Null values: N/A

This variable provides a unique value by which the redundant flight line data records can be stored, accessed, and retrieved for redundant encoding of target records. The link number is not a variable of statistical interest, since its purpose is the unique identification of inherently non-unique flight line numbers (see also FLINE and ORIENT) when oblique photography is involved. Hence, it does not appear as a variable in the SPSS data files. However, because of its uniqueness, it is used to label, i.e., name, the original data files. Rules for these file names are as follows:

1. The file name syntax: KFF123B (exploded: KF F 123 B)
2. Initials of hardware operator encoder, if more than one.
3. Alpha prefix (necessary if operator initials are not used)
4. Link number (constant for a given flight line and given orientation)
5. Alpha suffix (A-Z), if necessary (necessary when number of targets in given flight line, given orientation, exceeds 32 in number)



The link number is used twice: when encoding the redundant data at the terminal and again when accessing and retrieving that redundant data record during the target digitizing process. This redundant data record access and retrieval process also requires the use of two other variables, FLMLOT and FLMSEQ, in addition to LINK.

PHOTOGRAPHIC FRAME SEQUENCE IN ROLL ROLSEQ

File Specification	Field width	Card No.	Column No.
Original file	3	4	8-10
SPSS file	3	2	57-59

Possible values: 001-999

Null values: unknown -08

In each roll of film, the first frame and every fifth frame have been numbered. So, the first frame is frame number "1", the fifth frame is number "5", the tenth frame is number "10", etc. It is left for the film interpreter to determine the frame number of those frames between labeled (numbered) frames. The white, circular frame number label is affixed on the frame border on either the top or the bottom of the frame.

The frames are labeled consecutively through the entire roll of film, irrespective of the flight lines that occur within a film roll. Numbering the frames within each flight line was considered. This idea was discarded because this would make the numbering of the frames too complex and does not make finding a frame within a roll of film any easier.

There should be no consistency in the area covered by a specific frame number between flights, even though they are within the same flight line. This is because the area covered by the frame will vary between flights.

NOQUADS

TOTAL NUMBER OF QUADS COVERED BY PHOTO FRAME UNDER EXAMINATION

File Specification	Field width	Card No.	Column No.
Original file	2	4	14-15
SPSS file	2	4	20-21

Possible values: 01-04

Null values: Not applicable -9

A frame can cover up to 4 quads or be contained entirely within one quad. That is why four quad number variable are present. The number of quads value encoded for this variable should correspond to the number of times a quad number is entered for the quad number variables (QD1, QD2, Q3, QD4).

Topographic and orthophoto quad maps are used to (1) associate ground coordinates with points identified on the film, (2) provide a rough estimate of the area covered by a flight line. The method of locating ground control points on the imagery and quad maps will be discussed in greater detail under the description of digitizing control points.

There are 53 topographic and orthographic quad maps covering the study area. The quad maps have been arbitrarily numbered. A number was used to identify the map to cut down on the space needed to store the identifying information in a digital file. The lowest number applies to the most northern part of the study area and the highest number applies to the downstream portion of the study area.

PHOTOGRAPHIC FRAME AREAL COVERAGE - FIRST QUAD NUMBER QD1

File Specification	Field width	Card No.	Column No.
Original file	2	4	16-17
SPSS file	2	4	22-23

Possible values: 01-53

Null values: Not applicable -9

This variable is one of four quad numbers that could be imaged, within one frame of film. The number encoded is located at the lower right hand corner of each map. In general (for the set of variables QD1, QD2, QD3, QD4), the values must be mutually non-equal, i.e., QD1 $\neq$ QD2 $\neq$ QD3 $\neq$ QD4, unless the -9 (not applicable) value is encoded. QD1 may never equal -9, since at least one quad is always necessary when establishing ground control.

PHOTOGRAPHIC FRAME AREAL COVERAGE - SECOND QUAD NUMBER QD2

File Specification	Field width	Card No.	Column No.
Original file	2	4	18-19
SPSS file	2	4	24-25

Possible values: 01-53

Null values: Not applicable -9

This variable is one of four possible quad numbers that could be included within one frame of film. The number encoded is located at the lower right hand corner of each map. See also QD1.

PHOTOGRAPHIC FRAME AREAL COVERAGE - THIRD QUAD NUMBER QD3

File Specification	Field width	Card No.	Column No.
Original file	2	4	20-21
SPSS file	2	4	26-27

Possible values: 01-53

Null values: Not applicable -9

This variable is one of four possible quad numbers that could be included within one frame of film. The number encoded is located at the lower right hand corner of each map. See also QD1.

PHOTOGRAPHIC FRAME AREAL COVERAGE - FOURTH QUAD NUMBER QD4

File Specification	Field width	Card No.	Column No.
Original file	2	4	22-23
SPSS file	2	4	28-29

Possible values: 01-53

Null values: Not applicable -9

This variable is one of four possible quad numbers that could be included within one frame of film. The number encoded is located at the lower right hand corner of each map. See also QD1.

THE X VALUE FOR CONTROL POINT 1 - CP1X

File Specification	Field width	Card No.	Column No.
Original file	12	3	3-14
SPSS file	12	4	30-41

Possible values: All values must be positive numbers, measured in inches. Values greater than the width of the film image will not be accepted by the BDIGITIZ program.

Ground control points are fixed points which reference boat locations to latitude and longitude. Due to the oblique nature of the photography, the film has a distorted system of coordinates. This distortion in the film will be adjusted to conform with the coordinate system of the USGS topographic map through the use of ground control points that are the same on the map and film. The ground control points should be stable. This is not always possible and occasionally relatively unstable features must be used. The most important thing to do is to locate ground control points on the film which can be clearly and easily located on the USGS topographic map. The ground control point selected on the film must be the same as the one on the map.

Each ground control point has two values associated with it:
1) the X value of the control point (i.e., CP1X)
2) the Y value of the control point (i.e., CP1Y)

In the original data file, in the column before the control point value, is a control point number (i.e., control point one, has a control point number 1 in this column). This value has been dropped from use. It is not included in the file specification above.

To enter control points into the data record, the following general steps are followed:
1) Rotate and translate the digitizer tablet.
2) Select control points that are identifiable on the imagery and quad map.
3) Mark and label control points on the map.
4) Digitize the control points.

Each of these steps will be explained below.

1) Rotate and translate digitizing tablet

A) Place the cursor in the center of the rotate block. Depress the "1" key on the cursor keyboard.

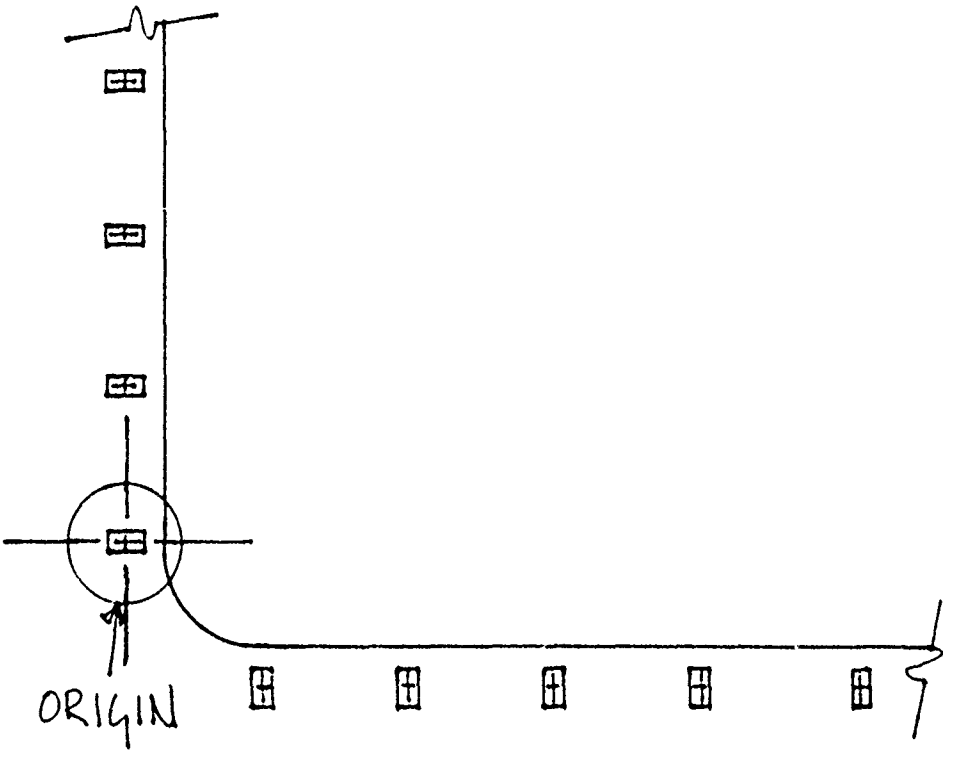
B) Place the cursor at the lower-left corner of the frame of the film to be analyzed, depress the "1" key on the tablet.

C) Place the cursor at the lower right-hand corner of the frame of film to be analyzed, depress the "1" key on the tablet.

D) Place the cursor in the middle of the translate block, depress the "1" key.

E) Place the cursor at the "0" block, depress the "1" key, then place the cursor on the CR block, depress the "1" key. Repeat this process. You have specified the origin to be 0,0.

F) Assign the 0, 0 point (the origin) to be the lower left corner of the frame. Do this by placing the crosshairs of the cursor over the lower left hand corner of the frame and depressing the "1" key, if the film is 70mm format. If the film has rounded corners, as was the case with the 9" x 9" format film obtained in the contract flight with Aerometric Engineering, Sheboygan, Wisconsin, another coordinate system origin must be determined. A convenient alternative was using the lowest crosshair image along the left margin of the photographic frame (see the figure below).

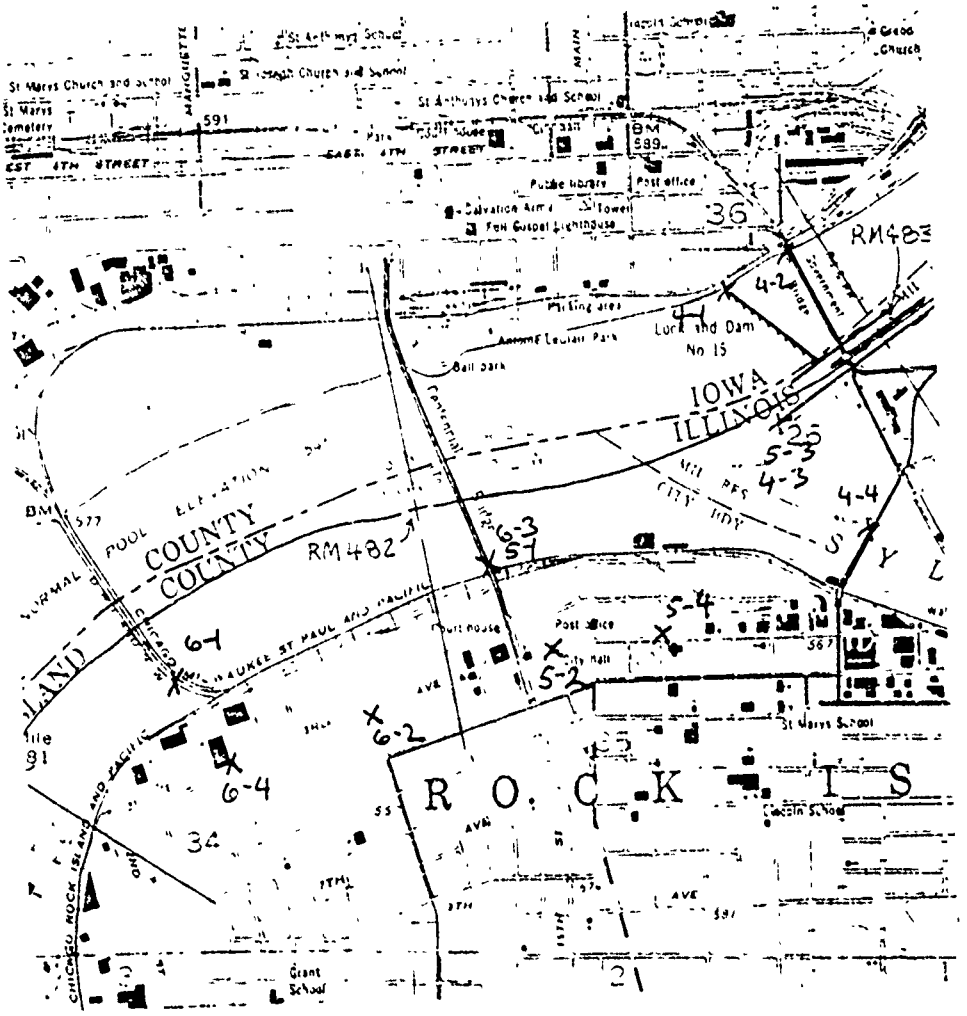


2) Select control points

The most important things to consider when selecting control points are:

A) They should be identifiable on both the quad map and the imagery. The exact point you digitize on the film should be locatable on the quad map.

B) The control points selected should be stable and relatively long lasting, that is they should not change over the course of five years.



In the figure above is a portion of a quad map with labeled control points. Notice which control points were selected.

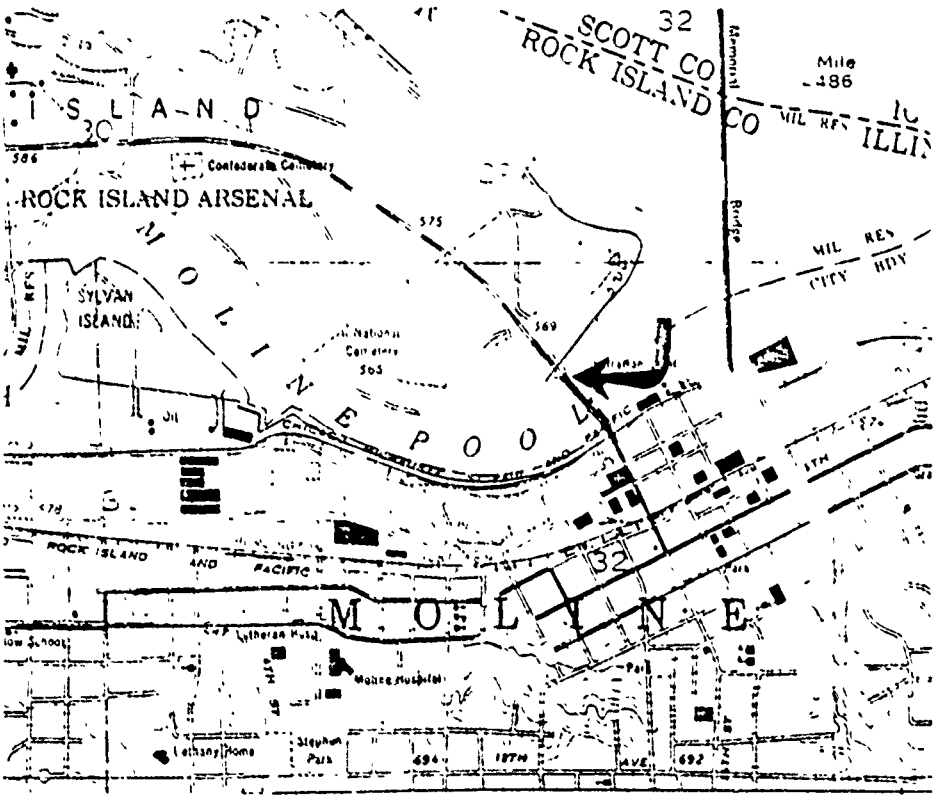
3) Labeling Control Points

With a fine pointed pencil, locate the ground control point on the map overlay (the mylar sheet), with an X. Write any comments that help locate the ground control point beside the "X". Number the ground control point with the frame number within the flight line and with the ground control point number within the frame of film. See example.

4) Digitize the Control Points

Digitize the control points in sequence with the prompting messages provided by the BDIGITIZ program. A message will be printed on the screen "Digitize first control point." Place the crosshairs over the desired control point. Depress the "1" key to digitize control point one, the "2" key for control point two, etc. If you make a mistake while digitizing control points you can start the process over by depressing the "1" key. This will automatically start the digitizing process over. If you have digitized all four control points and you want to do them over, key in a "Y" to the message "Do you want to do Cntrl Pts over?" that will appear on the screen after the fourth control point is digitized.

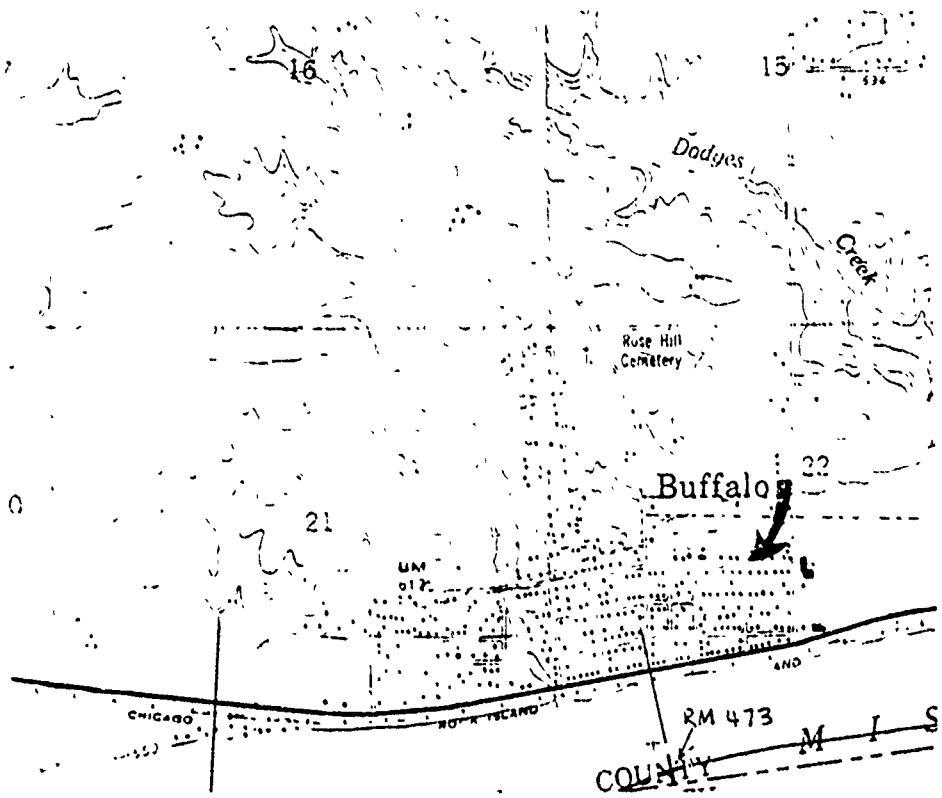
Bridges - Use the intersection of the bridge and the shore line, or the intersection of the bridge with a road.



Portion of a quad map showing the part of the bridge which is used as a control point.

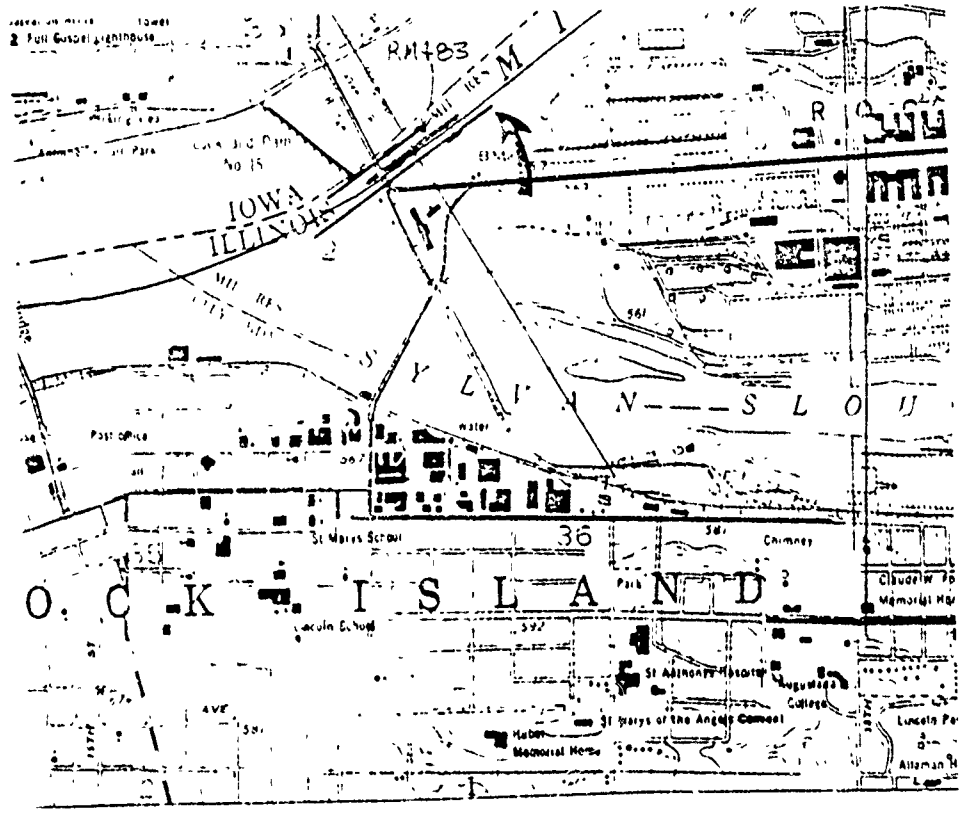
Listed below are suggested ground control points and rules for their use

Road intersections - Place cursor in exact center of intersections or at a corner of the intersection. Be sure and indicate the point digitized clearly on the map sheet.



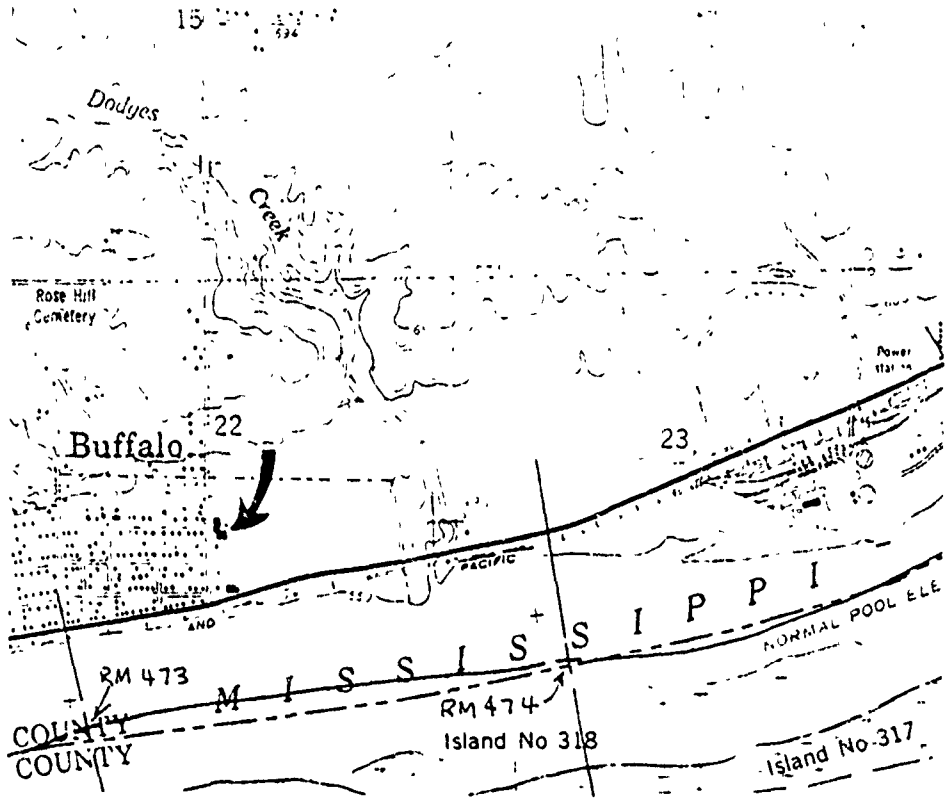
Portion of quad map showing the road intersection that could be used as a control point.

Locks - For locks place cursor on the ends of the walls of the locks.



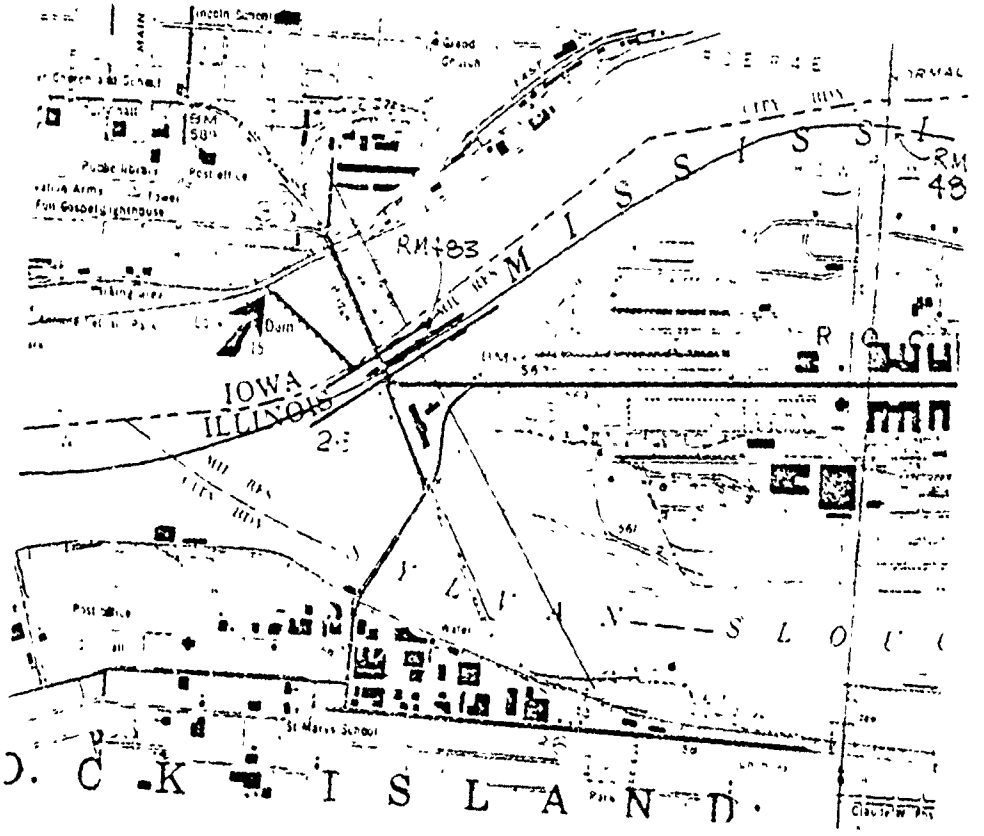
Portion of quad map showing the part of lock that could be used as a control point.

Structures - If possible, define a corner of the structure that is identifiable on both the film and the map.



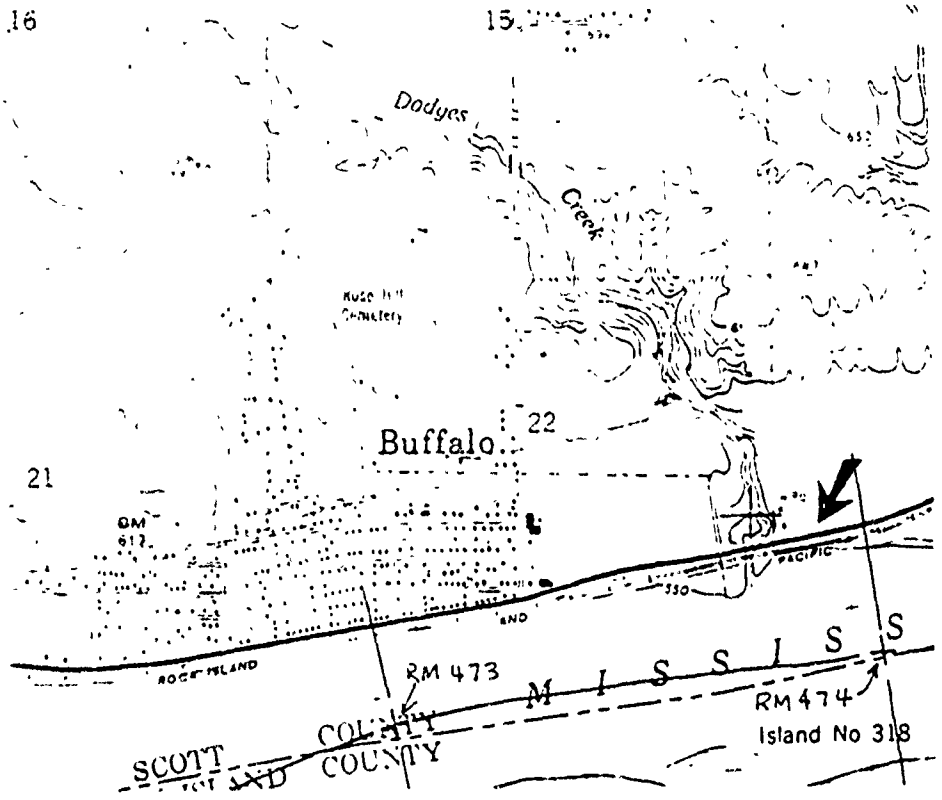
Portion of quad map showing the structure that could be used as a control point.

Dams - Place cursor at the intersection of the dam and the shore line.



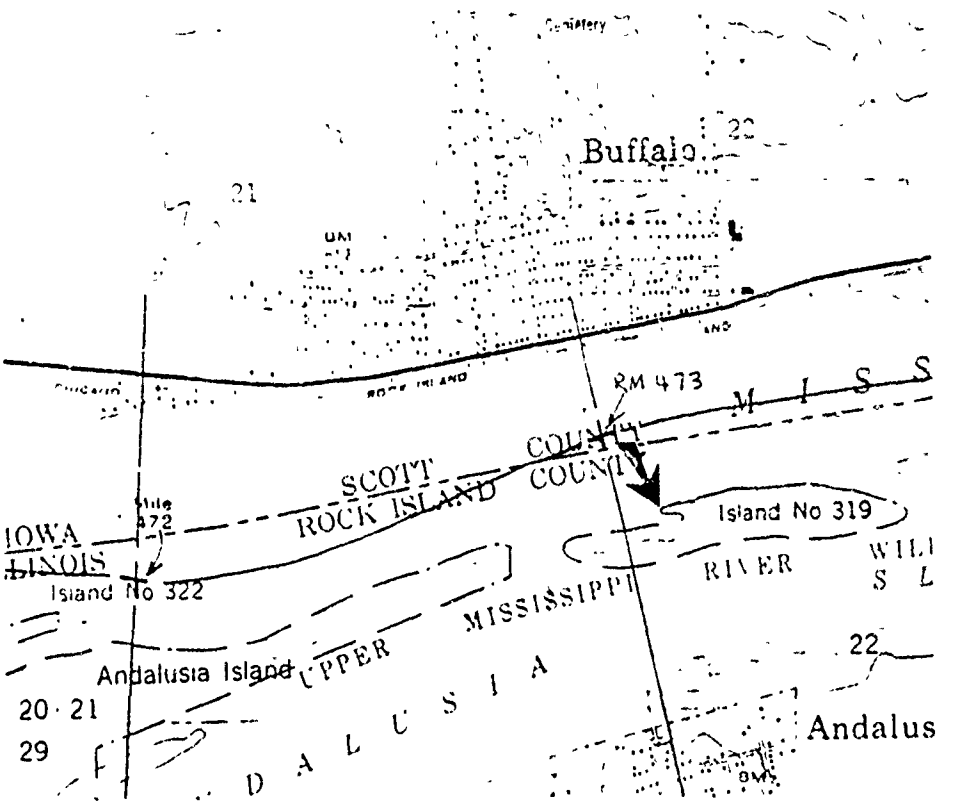
Portion of quad map showing the part of the dam used as control point.

Vegetation Patterns - Although not as stable as structures, they can be used if no better control points are available. Use sharp, distinguishable features in the vegetation pattern. An example of this is a corner of a field adjacent to tree cover.



Portion of quad map showing the vegetation pattern that could be used as a control point.

Shoreline Patterns - These features include islands and distinguishable irregularities in the shoreline. They are not as stable as structures, but they can be used when no other control points are available. The tips or points of islands, mouths of bays, and creek inlets are examples of shoreline patterns. On islands, a stable bank or shore can be indicated by old growth tree cover, as opposed to the emergent aquatics. Try to use the most stable appearing point on the shoreline pattern.



Portion of the quad map showing the shoreline pattern (tip of the island) that could be used as a control point.

THE Y VALUE FOR CONTROL POINT 1 CP1Y

File Specification	Field width	Card No.	Column No.
Original file	12	3	16-27
SPSS file	12	4	42-53

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE Y VALUE FOR CONTROL POINT 2 CP2X

File Specification	Field width	Card No.	Column No.
Original file	12	3	30-41
SPSS file	12	4	54-65

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE X VALUE FOR CONTROL POINT 3 CP2Y

File Specification	Field width	Card No.	Column No.
Original file	12	3	43-54
SPSS file	12	4	66-77

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE Y VALUE FOR CONTROL POINT 3 CP3X

File Specification	Field width	Card No.	Column No.
Original file	12	3	57-68
SPSS file	12	5	30-41

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE X VALUE FOR CONTROL POINT 4 CP3Y

File Specification	Field width	Card No.	Column No.
Original file	12	3	70-81
SPSS file	12	5	42-53

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE X VALUE FOR CONTROL POINT 4 CP4X

File Specification	Field width	Card No.	Column No.
Original file	12	3	84-95
SPSS file	12	5	54-65

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

THE Y VALUE FOR CONTROL POINT 4 CP4Y

File Specification	Field width	Card No.	Column No.
Original file	12	3	97-108
SPSS file	12	5	66-77

Possible values: See under CP1X

Refer to CP1X for a description of this variable.

TYPE OF TARGET TARGET

File Specification	Field width	Card No.	Column No.
Original file	2	2	26-27
SPSS file	2	3	20-21

Possible values:

Boats	
Canoe	01
Rowboat, no motor	02
Inflatable	03
Sailboat (under sail)	04
Sailboat (not under sail)	05
Open-hulled boat	06
Decked-hulled boat	07
Pontoon boat	08
House boat	09
Barge or barges, no tow	10
Barge(s) and tow	11
Tow only	12
Excursion boat (river boat)	13
Other Features	
Duckblind	20
Covered boat slip	30
Empty open slip	31
Small uncovered dock (space for 4 craft)	40
Large uncovered dock (space for over 4 craft)	41
Covered dock (not a single covered slip)	42
Industrial/commercial dock	44

The target's location and type is entered into the data record similar to the process described under control points. Follow the steps below:

Digitizing the Boat Location and Keying in the Craft Type

1. Place the crosshairs directly over the center of the target. Depress the "D" key.
2. Next, enter the code to identify the target.
3. Depress the "#" key to indicate you are through digitizing.
4. If the values have been accepted, the BDIGITIZ program will print the message "Do you want to do this over?" If yes, key in a "Y". If no, hit the return key and continue coding data.

On the following pages is an interpretive key for each target type. Two photographs are included to aid interpretation. One, a print of the frame that contains the feature of interest with no

enlargement. Two, an enlargement of the feature (enlargement factor from 10x to 30x, depending on the size of the feature covered) is provided. These photos are similar to the way the feature would look if viewed through the Bausch and Lomb Zoom Stereoscope under magnification. The photos are much fuzzer than those viewed through the Bausch and Lomb Stereoscope. The photo enlargement process accounts for this. The film scratches seen on the imagery inevitably occur when the film is analyzed. They are accentuated. The rowboat and the inflatable target type are not described because they were seen very rarely on the river.

TARGET

01
Canoe

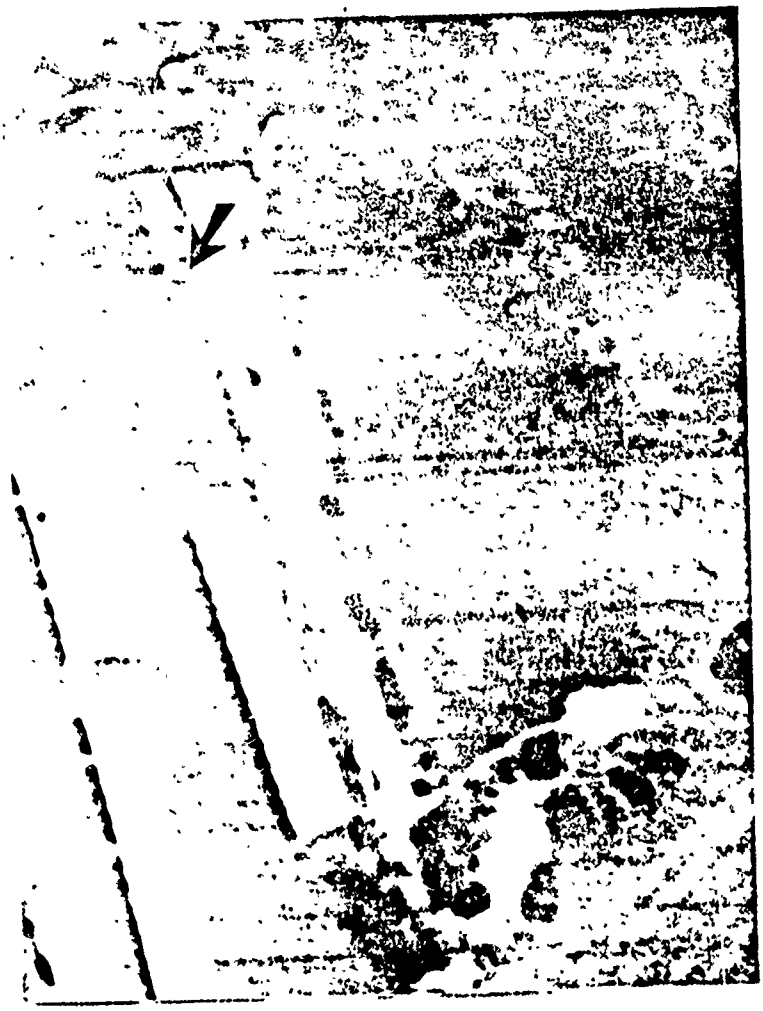
Primary distinguishing characteristics are the lack of a motor and wake, the high length to width ratio, the pointed bow and stern, the elongated shape, and the small size (under 20 feet). The paddles are sometimes visible. They appear as light, ill-defined objects protruding from either side of the canoe, [illegible] the person might sit. Secondary distinguishing characteristics [illegible]e the lack of sails, pontoons, and decks. The wake is very [illegible]lt to see, being low in contrast to the surrounding water, and the angle is narrow. The wake is not churny.



Print of frame showing beached canoe amid open-hulled boats.

TARGET

01
Canoe
Enlargement

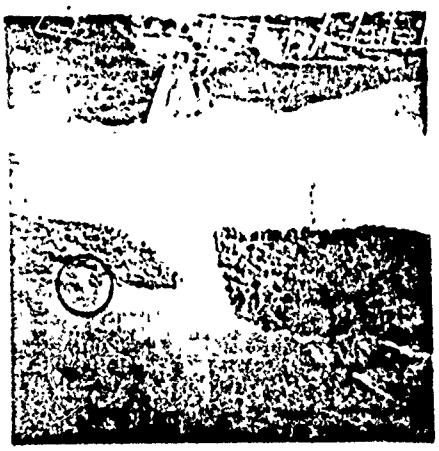


Canoe, 20x magnification.

TARGET

04, 05
Sailboat (including under sail and not under sail)

The primary distinguishing characteristics are the presence of sails or masts. Secondary characteristics include the hardly visible wake, the elongated shape, the pointed bow, the tapered and/or rounded stern, and the presence of decks. Two types of sailboats exist. The single hulled, and the double-hulled catamaran. The catamaran is shown in the photograph. The presence of sails indicates the target is underway and determines if the target should receive a 04 code. The absence of sails indicates the 05 value should be used to code the target.



Print of frame showing sailboat beached on shore.

TARGET

04
Sailboat
Enlargement

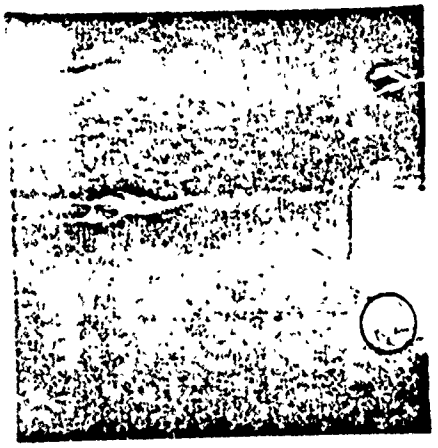


Sailboat, Catamaran type, 30x magnification.

TARGET

06
Open-Hulled Boat

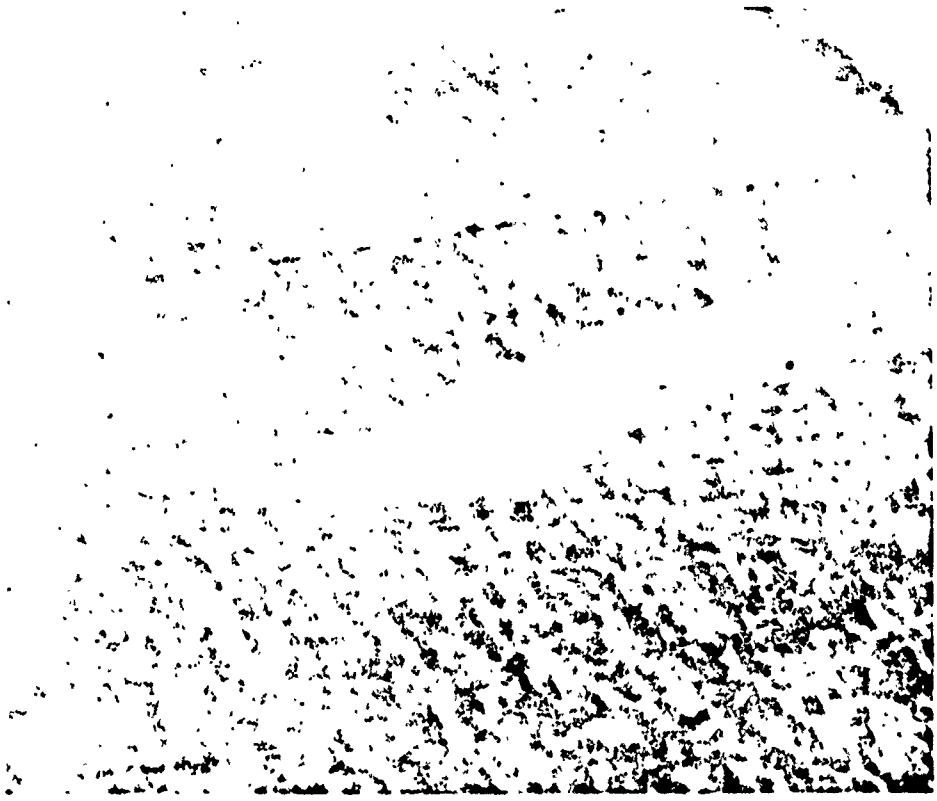
The primary distinguishing characteristics are the absence of decks and the relatively small size. The bow can be pointed, blunt, rounded or squared-off. The stern is always squared off. The overall shape can be elongated or rectangular (with rounded or squared corners). The relative size is small to medium in length (under 20 to 40 feet). The wake is of high contrast to the surrounding water, which indicates a craft capable of relatively high speeds. The wake is usually wider than the boat, where it originates near the stern of the boat. The angle of the wake is narrow at high speeds and wider at lower speeds. The wake is not likely to be churny (typical of barges).



Print of frame showing open-hulled boat.

TARGET

06
Open-hulled boat
Enlargement



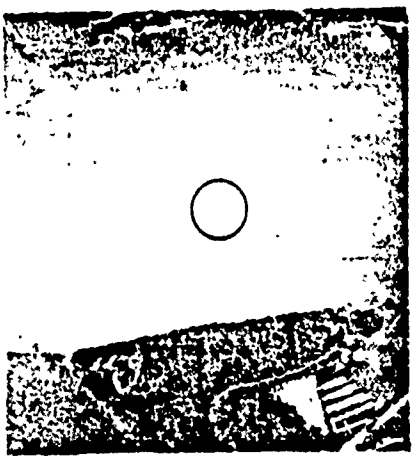
Open-hulled boat, 20x magnification.

TARGET

07

Decked-Hull Boat

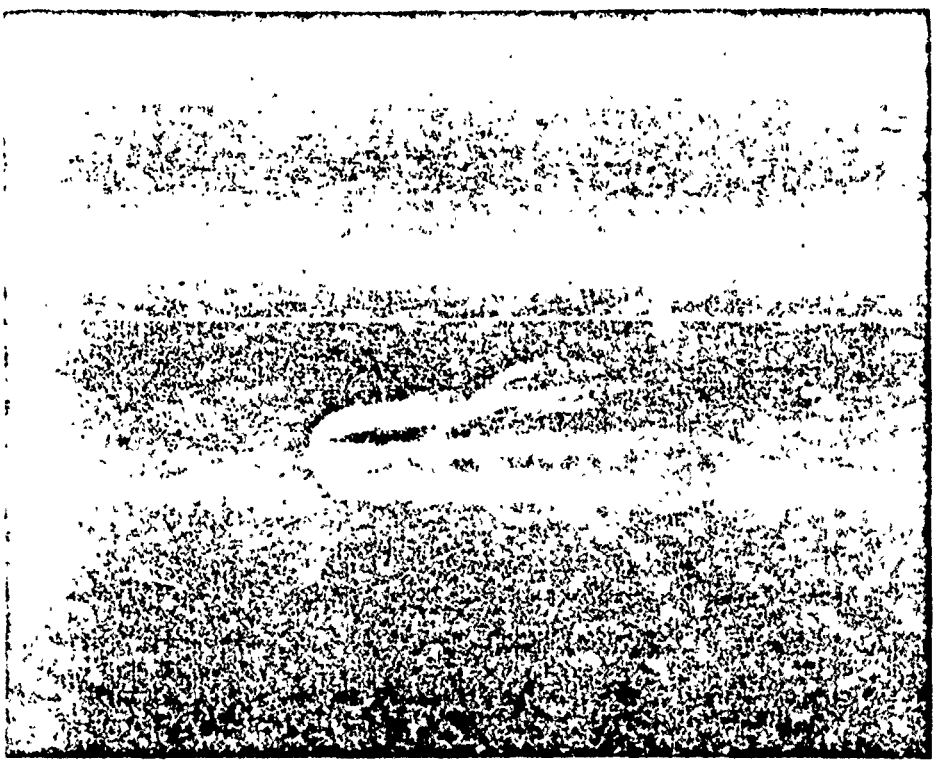
The primary distinguishing characteristics are the multiple decks and pointed bow. The bow of the boat is also free of cabin space. A houseboat, which may have multiple decks, can have cabin space directly over the bow of the boat. Houseboats usually have square bows. Secondary identifying characteristics are: the stern is always squared off; the overall shape is either elongated, or rectangular (with rounded or squared off corners); the size is variable, ranging from under 20 feet to over 60 feet in length; no masts, pontoons, paddles, or inflation devices are every present; sometimes at the stern of the boat the open cockpit is visible; the wak at high speeds can be narrow, at lower speeds it is wider; and the wake is not churny.



Print of frame showing decked-hull boat, motor powered.

TARGET

07
Decked-hull boat
Enlargement

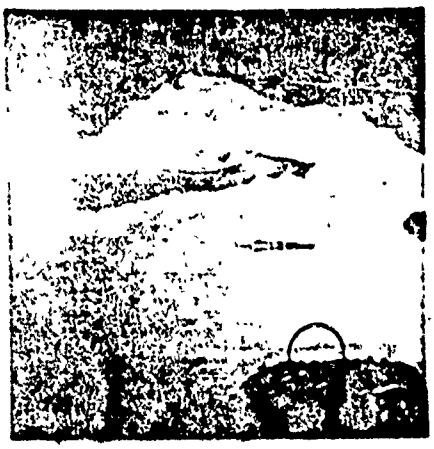


Decked-hull boat, 20x magnification.

TARGET

08
Pontoon Boat

The primary distinguishing characteristics are pontoons which protrude beyond the deck, a squared off bow and stern, and an overall shape that is rectangular. Secondary distinguishing characteristics are its small to moderate size (under 20 to 40 feet in length), the presence of a motor(s), lack of sails, and lack of decks. The wake can have a low or high contrast to the surrounding water. The angle of the wake is wide. The wake is not churny.



Print of frame showing pontoon boat.

TARGET

08
Pontoon boat
Enlargement



Pontoon boat, beached amid other craft, 30x magnification.

TARGET

09

House Boat

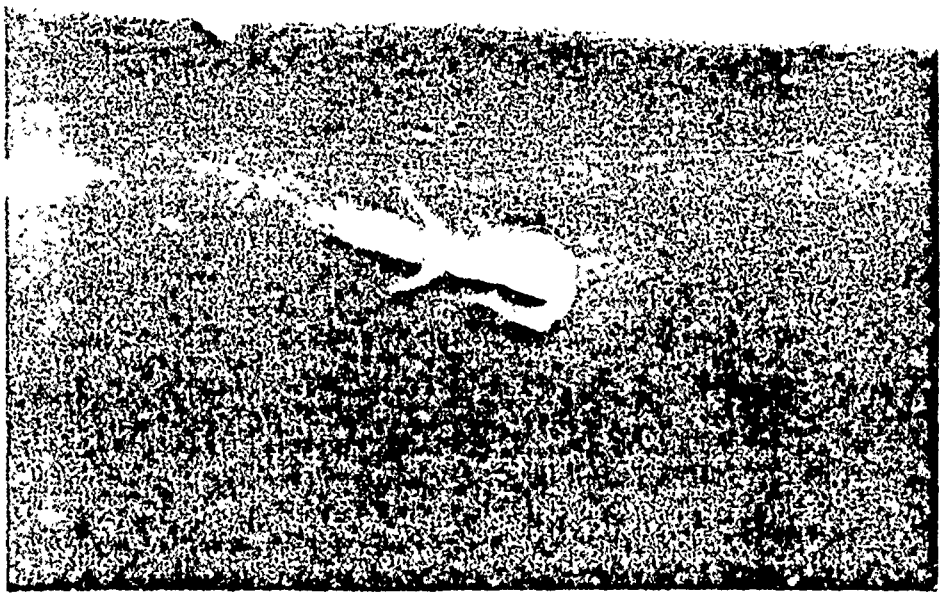
The primary distinguishing characteristics are the presence of multiple decks and the squared-off or rounded stern and bow. Secondary distinguishing characteristics are cabin space occurring directly over the bow, the rectangular shape (with rounded or squared off corners), the medium to large size (20 to over 40 feet in length), the lack of sails, paddles, or flotation devices. The wake can have low or high contrast to the surrounding water and is wide. The wake is not churny.



Print of frame showing houseboat.

TARGET

09
Houseboat
Enlargement



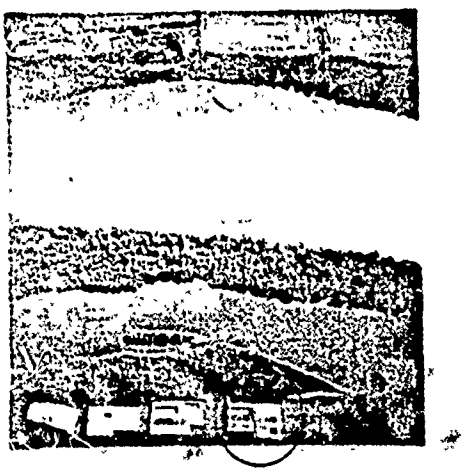
House boat, 30x magnification.

TARGET

10

Barge or Barges, No Tow Boat

The primary distinguishing characteristics of the barge(s) without a tow are the high length to width ratio, squared-off bow and stern, the large size, rectangular shape, and its presence only in the main channel. Secondary distinguishing characteristics include the characteristic grouping of several barges, and the presence of the holds or storage bins on the barges.

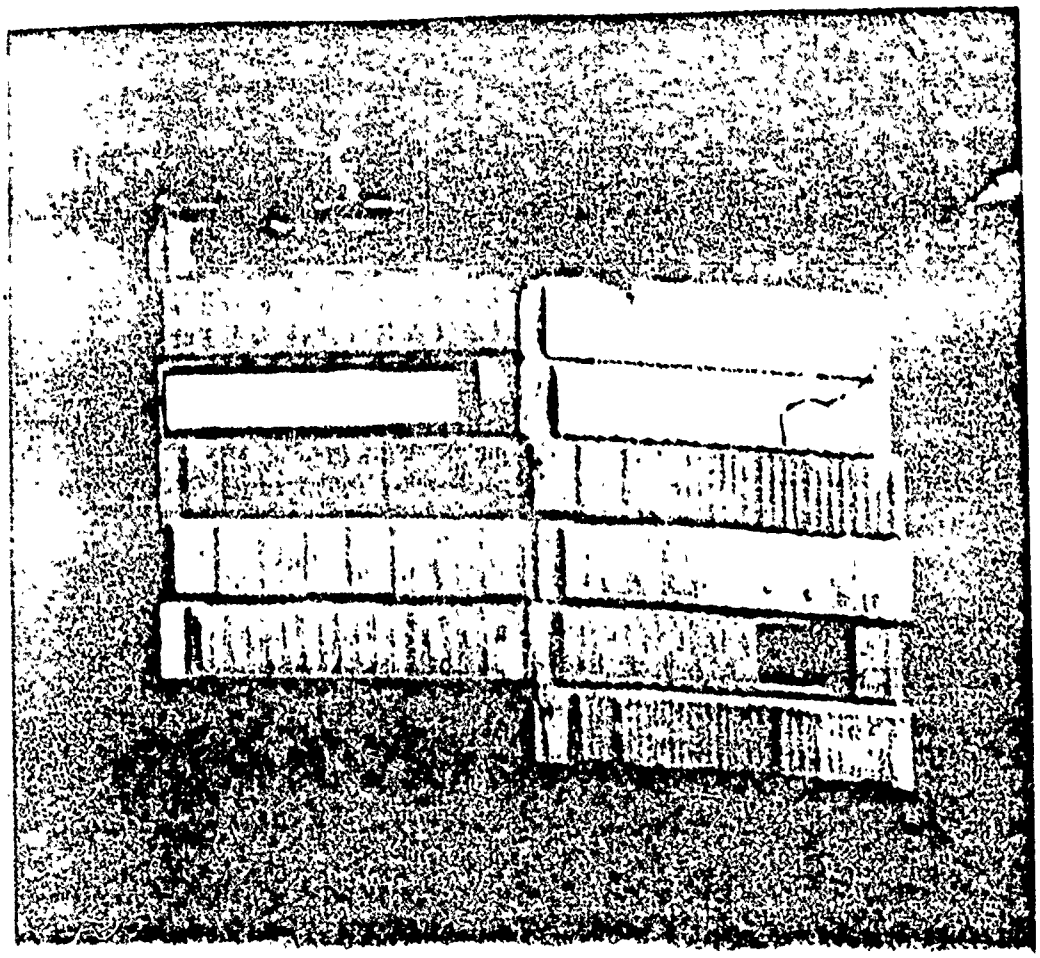


Print of frame showing barges with no tow boat.

TARGET

10

Barge or Barges, No Tow Boat
Enlargement



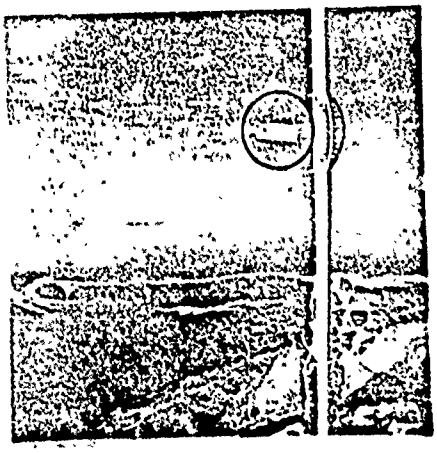
Barges, 15x magnification.

TARGET

11

Barge(s) and Tow

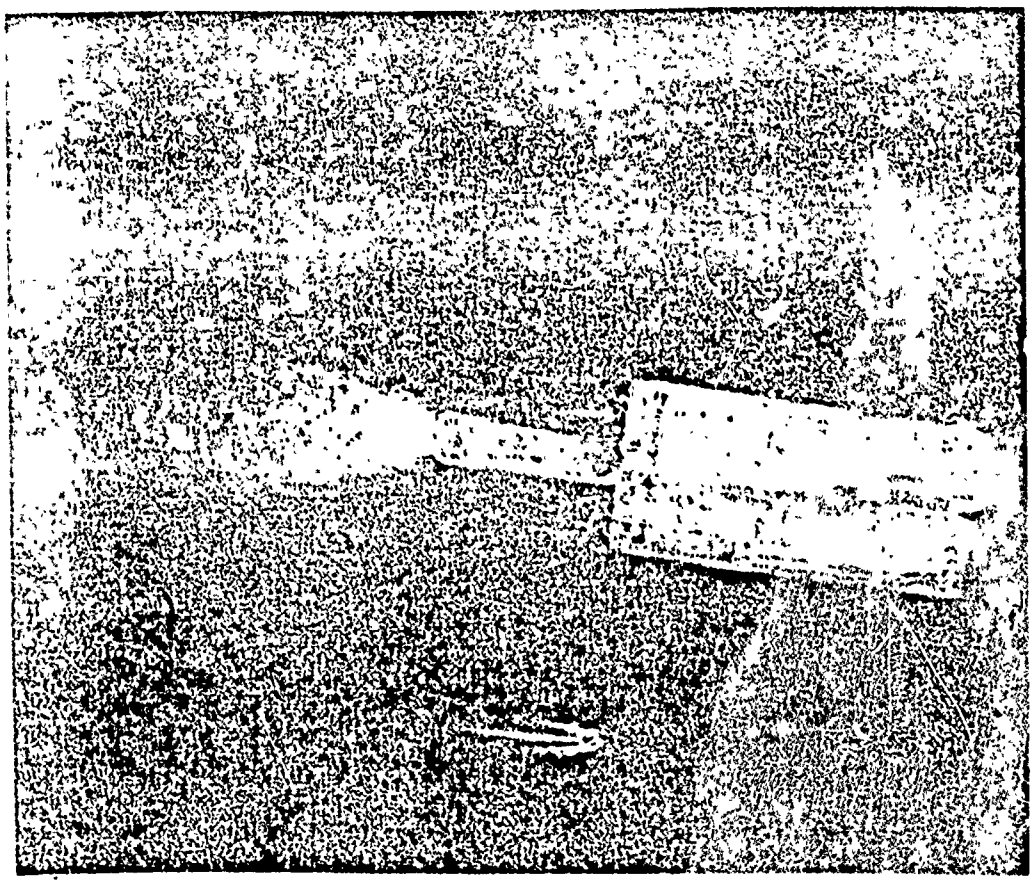
The barge/tow complex refers to the barge tow and barges combined. Primary distinguishing characteristics are the association of several barges with one tow, squared-off stern and bow, the rectangular overall shape, the large overall size, the churny wake, and its presence in the main channel. A secondary distinguishing characteristic is the presence of the individual storage bins on the barges.



Print of frame with barge(s) and tow boat.

TARGET

11
Barge(s) and Tow
Enlargement

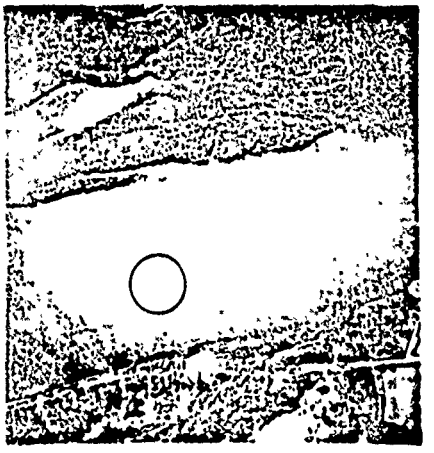


Barges and tow boat, 15x magnification.

TARGET

12
Tow Boat

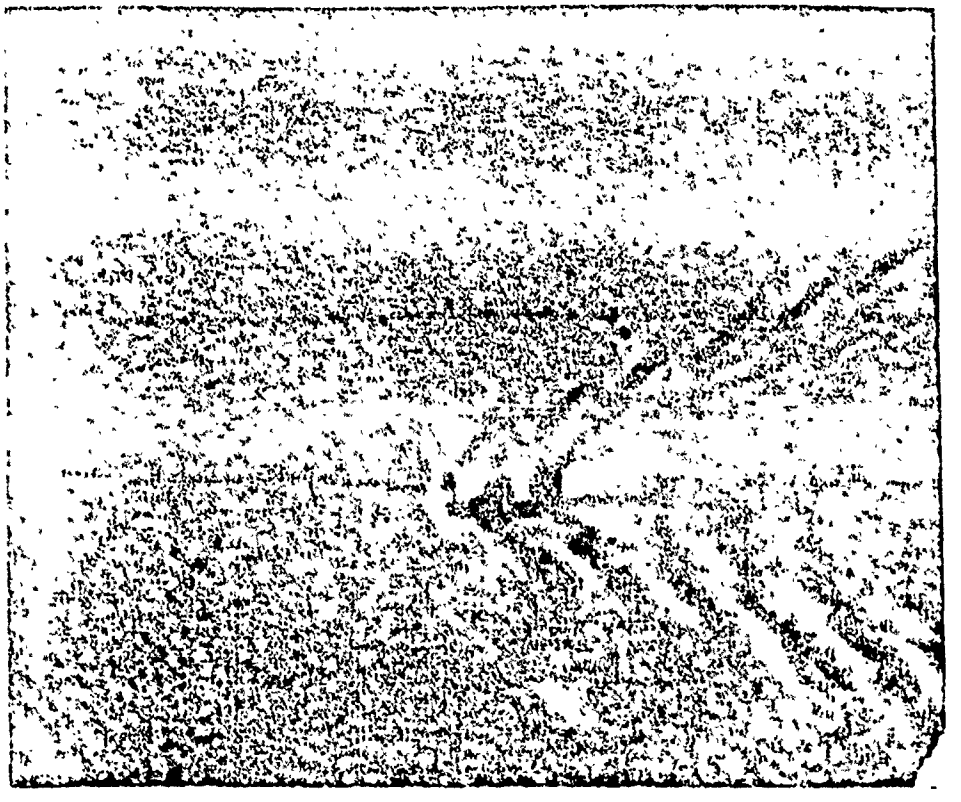
The primary distinguishing characteristics of the tow boat are the pilot house on the second deck, the squared off bow and stern, the rectangular overall shape, the churny wake, and the tow's usual location in the main channel. Secondary distinguishing characteristics are the presence of multiple decks, and the wide angle of the wake.



Print of frame with tow boat.

TARGET

12
Tow boat
Enlargement



Tow only, 30x magnification.

TARGET

13

Excursion Boat

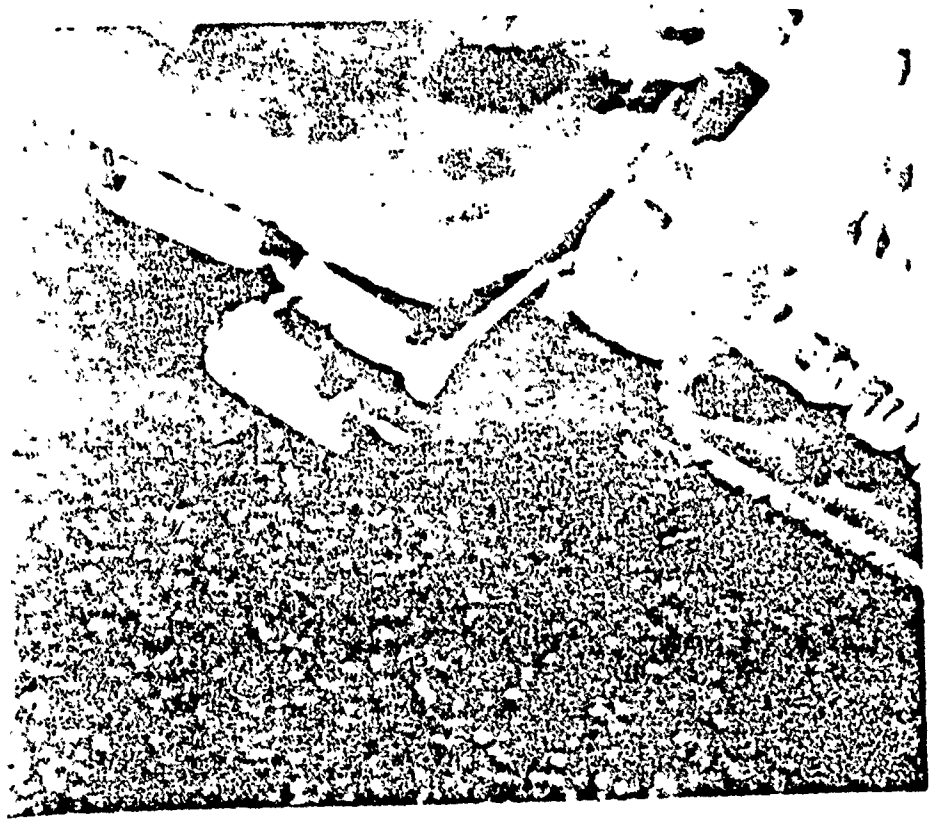
The primary distinguishing characteristics of the excursion boat are the large overall shape, the churny wake, and the mounting for a paddlewheel at the stern, and its usual location in the main channel. Secondary distinguishing characteristics include the possible rounded or curved bow (it could be squared) and the presence of multiple decks.



Print of frame with excursion boat.

TARGET

13
Excursion boat
Enlargement



Excursion boat, 30x magnification.

TARGET

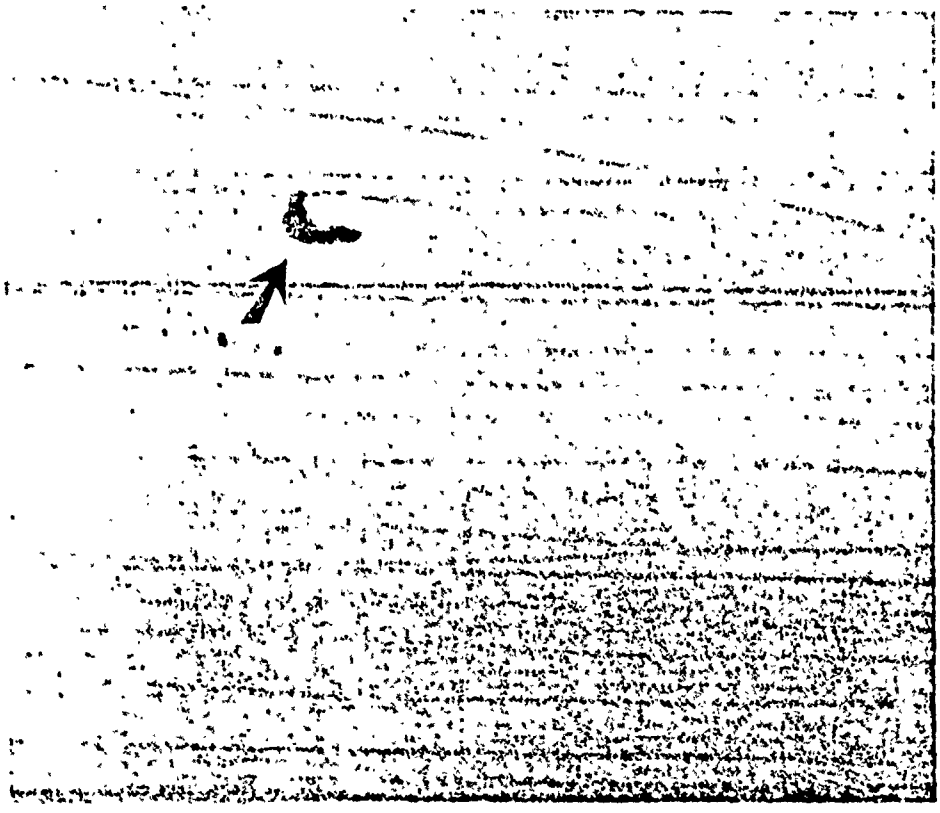
20
Duck Blind

The primary distinguishing characteristics are the square shape, and the shadow that borders one side of the blind. Secondary distinguishing characteristics include the light color of the wood used to build the blind, vegetation affixed to the blind, and small boats moored next to the blind.



Print of frame with duck blinds.

TARGET
20
Duck blind
Enlargement



Duck blind, 20x magnification.

TARGET

30

Covered Boat Slip

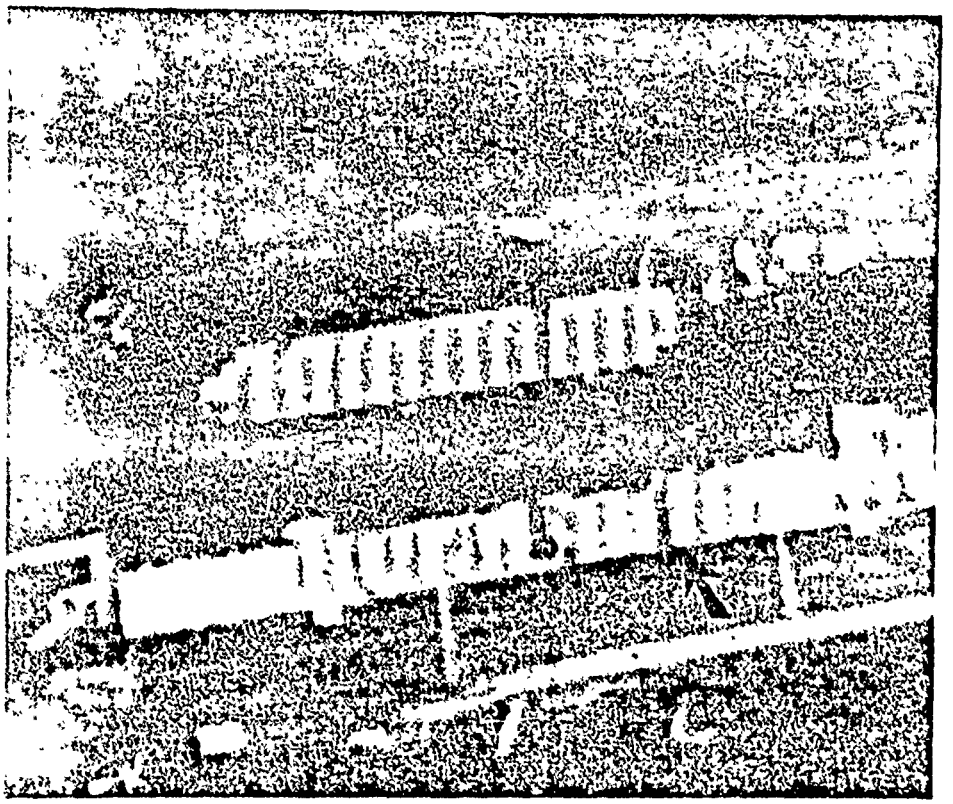
Covered boat slips are individual slips with covers or roofs. They house only one boat. They are usually located at marinas. They can be identified by their square shape, and the arrangement in a row along the marina dock. Occasionally covered slips away from marinas occur.



Print of frame with covered boat slip.

TARGET

30
Covered boat slip
Enlargement



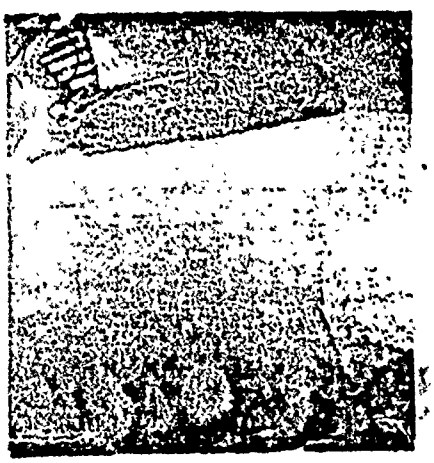
Covered boat slip, 20x magnification.

TARGET

31

Empty Boat Slip

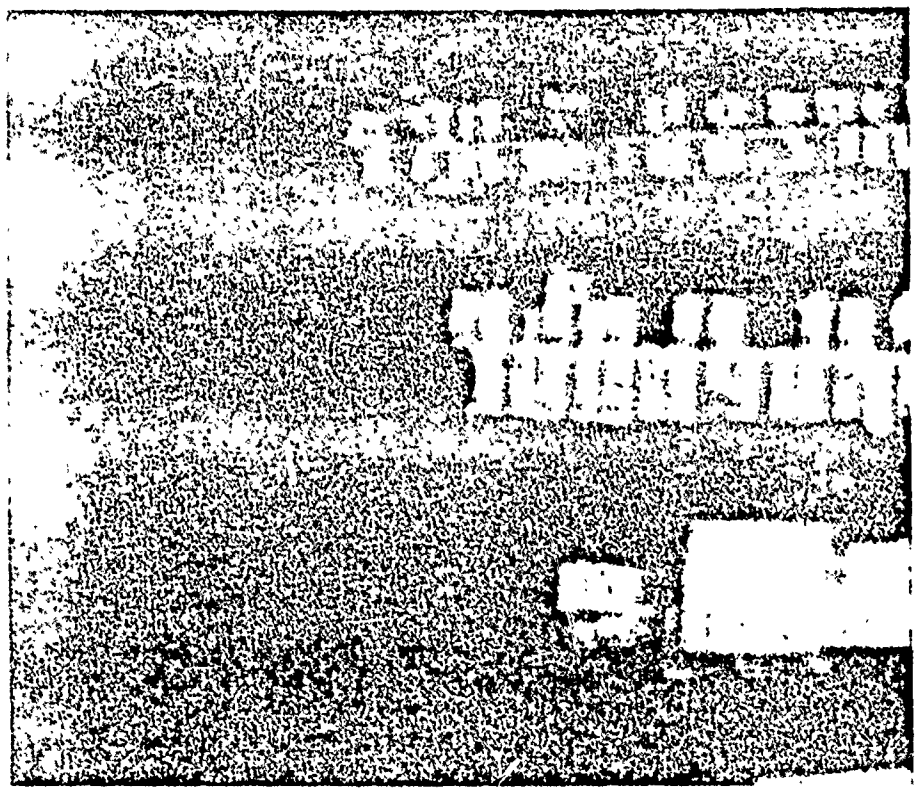
An empty boat slip is a space at a large dock that could contain a boat. It can be bordered by a walkway on either side or by a boat. Empty slips are only observed where the boats are docked perpendicular to the main dock. Simply stated, an empty boat slip is a space at a dock that could hold one boat. The size of the boat determines the size of the empty slip is based on surrounding, docked boats.



Print of frame, empty boat slip.

TARGET

31
Empty Boat Slip
Enlargement



Empty boat slip, 20x magnification.

TARGET

40

Small Uncovered Dock

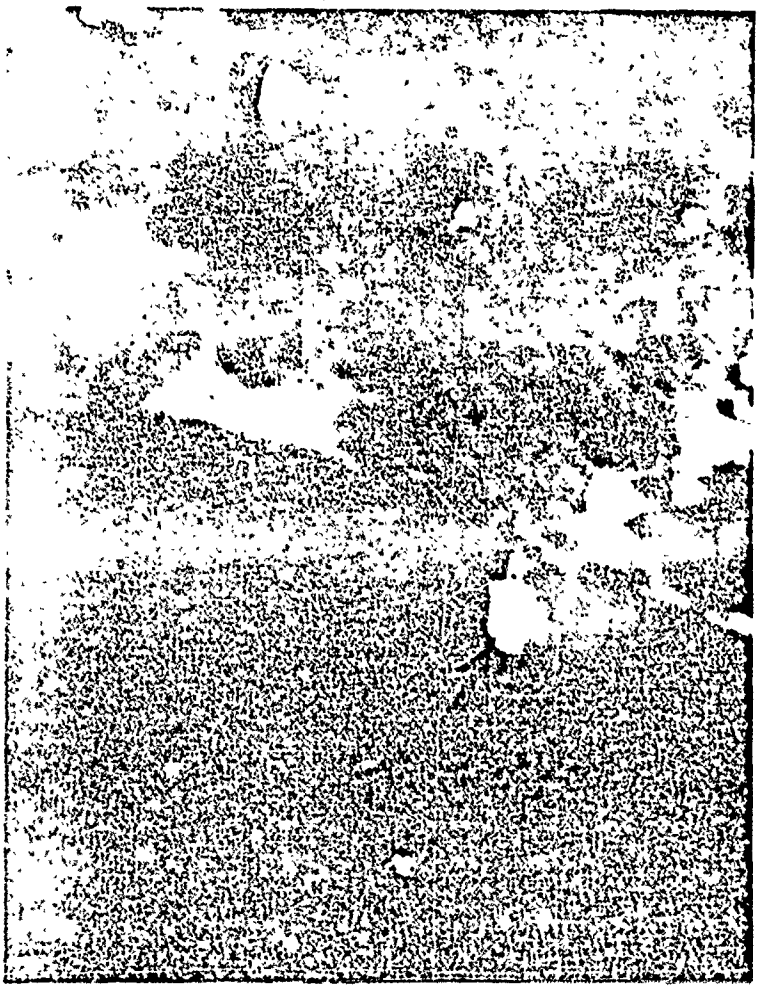
Small uncovered docks are those that can hold no more than 4 boats. The amount of boats the dock can hold is based on an estimate by the interpreter. This overlaps with the large uncovered dock because the number of boats a dock can hold is dependent on the position the boats are in when attached to the dock.



Print of frame containing small uncovered dock.

TARGET

40
Small uncovered dock
Enlargement



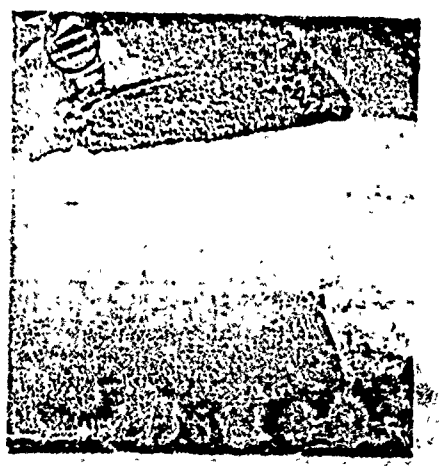
Small uncovered dock, 20x magnification.

TARGET

41

Large Uncovered Dock

Larger uncovered docks are those that can hold over 4 boats. The amount of boats the dock can hold is based on an estimate by the interpreter. This interpretation overlaps with the small uncovered dock interpretation because the number of boats a dock can hold is dependent on the position the boats are in when attached to the dock.



Print of frame containing large uncovered dock.

TARGET

41
Large Uncovered Dock
Enlargement



Large uncovered dock, 20x magnification.

TARGET

44

Industrial/Commercial Dock

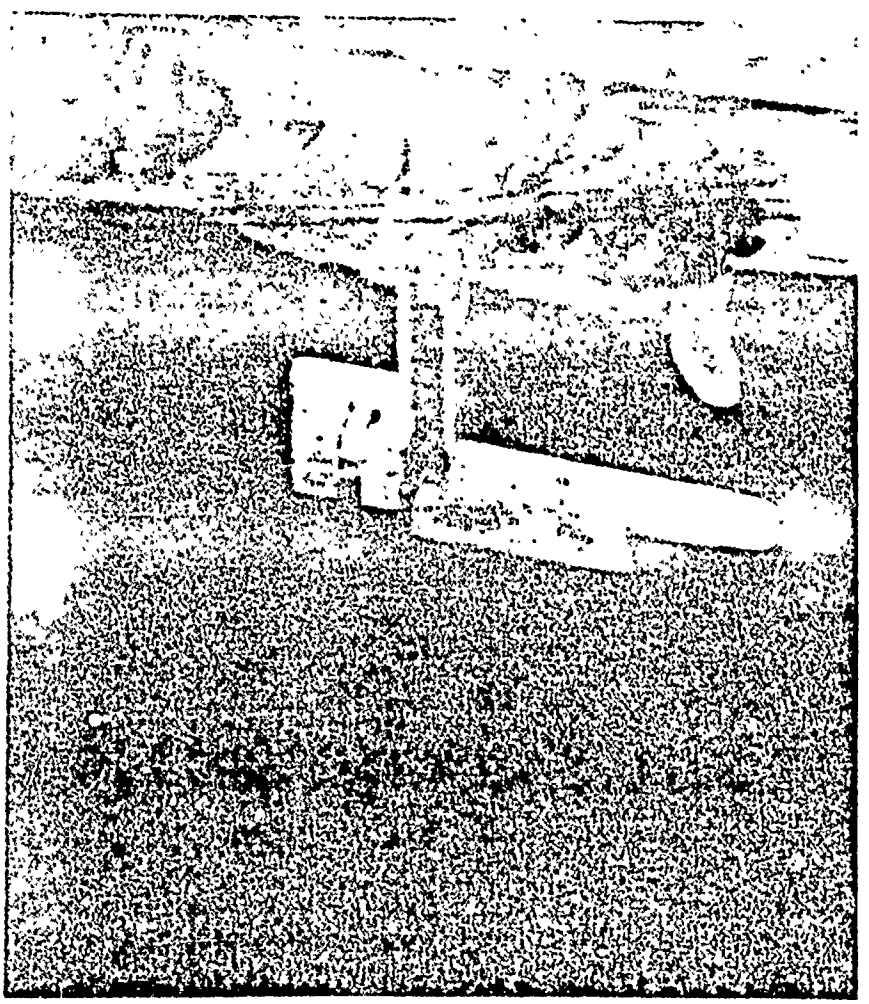
Industrial/commercial docks are those barges use. They are recognized by the round pilings that are located around the dock, their relatively large size, the presence of barges around the dock, and the factory or industrial site located next to the dock. Occasionally the unloading/loading apparatus such as a conveyer or pipe will be noticed.



Print of frame containing industrial/commercial dock.

TARGET

44
Industrial/Commercial Dock
Enlargement



Industrial/Commercial Dock, 30x magnification.

TARGET

02
Rowboat, No Motor

The primary distinguishing characteristics are the small size, the absence of a motor, presence of paddles or oars, and the squared off stern. Secondary distinguishing characteristics include: the low to medium length width ratio, the pointed (blunt), rounded, or squared-off bow, the elongated or rectangular shape, and the lack of sails, decks, pontoons, or inflation devices, the wake is low in contrast to the surrounding water, is narrow to wide, is not churny, and may be impossible to see. This boat type was not interpreted with sureness. Hence, a photo cannot be provided.

03
Inflatable Boat

The primary distinguishing characteristics of the inflatable are the low to medium width ratio of the curved bow, the oval shape, the small size (under 20 feet), the presence of paddles, and the presence of inflation devices. This boat type was not interpreted with sureness. Hence, a photo cannot be provided.

TARGET X COORDINATE TARCOX

File Specification	Field width	Card No.	Column No.
Original file	12	2	1-12
SPSS file	12	3	22-33

Possible values: The X coordinate is a distance from the lower lefr corner of the frame of film (0, 0). Distances that are greater than the width of the film or negative values are invalid.

TARGET Y COORDINATES TARCOY

File Specification	Field width	Card No.	Column No.
Original file	12	2	14-25
SPSS file	12	3	34-45

Possible values: The Y coordinate is a distance from the lower left corner of the frame of film (0, 0). Distances that are greater than the width of the film or negative values are invalid.

LOCATION OF TARGET TO NEAREST RIVERMILE RMILE

File Specification	Field width	Card No.	Column No.
Original file	4	4	42-45
SPSS file	4	3	46-49

Possible values: 0001-9999

Null values: unknown -0008

The river mile variable locates the target digitized. The river mile has been written on the quad maps. The river mile values were taken from the U.S. Corps of Engineers navigation maps. The river mile values are distances measured (in miles) from the mouth of the river. The interpreter checks the quad map and encodes the closest river mile to the target.

The location of targets halfway between two river mile points is sometimes difficult to decide. No rule for deciding which river mile value to encode for the target was formulated.

RIMILE has been used in place of RMILE in some instances.

CONFIDENCE LEVEL OF TARGET TYPE CLASSIFICATION CONF

File Specification	Field width	Card No.	Column No.
Original file	2	4	47-48
SPSS file	2	3	50-51

Possible values:	Value
Very sure of classification (one logical choice)	01
Educated guess (could be two choices)	02
Unsure (no idea of what the target is)	03

Null values: not applicable -9

This variable measures the degree that the interpreter is confident in the identification of the target. Many factors could make it hard to identify the target. The interpreter has the opportunity to encode up to four reasons for any difficulty encountered with interpretation. If the 01 value is entered into the data file (very sure of classification), then no unsure classification variables should be entered (except the -9 value, not applicable). The unsure classification variables are named WHY1, WHY2, WHY3, and WHY4.

FIRST REASON FOR UNSURE TARGET CLASSIFICATION WHY1

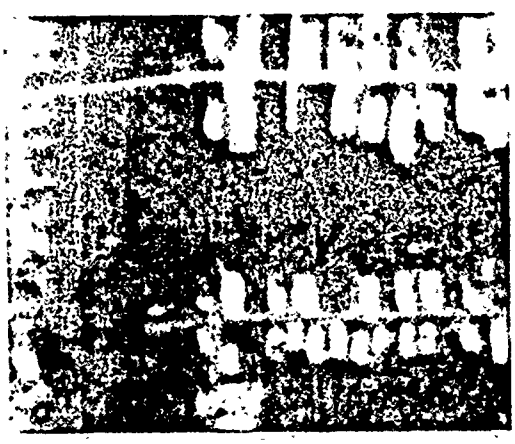
File Specification	Field width	Card No.	Column No.
Original file	2	4	49-50
SPSS file	2	3	52-53

Possible values:	Value
Shape not well-defined	01
Location in river questionable	02
Target cut by frame boundary	03
Target obscured by cloud cover	04
Target obscured by cloud shadow	05
Target hidden by tree canopy	06
Glare	07
General underexposure of imagery	08
General overexposure of imagery	09

Null values: not applicable -9

Explanation of each kind of unsure classification follows.

01
Shape not well defined - when the shape is not well defined, it is difficult to see features on the target that allow you to distinguish the target from other types. When boats are docked or are located within a marina, it sometimes is difficult to see the shape of the boat, or decks on the boat. This is necause the shape of the boat is obscured by being so close to the dock.



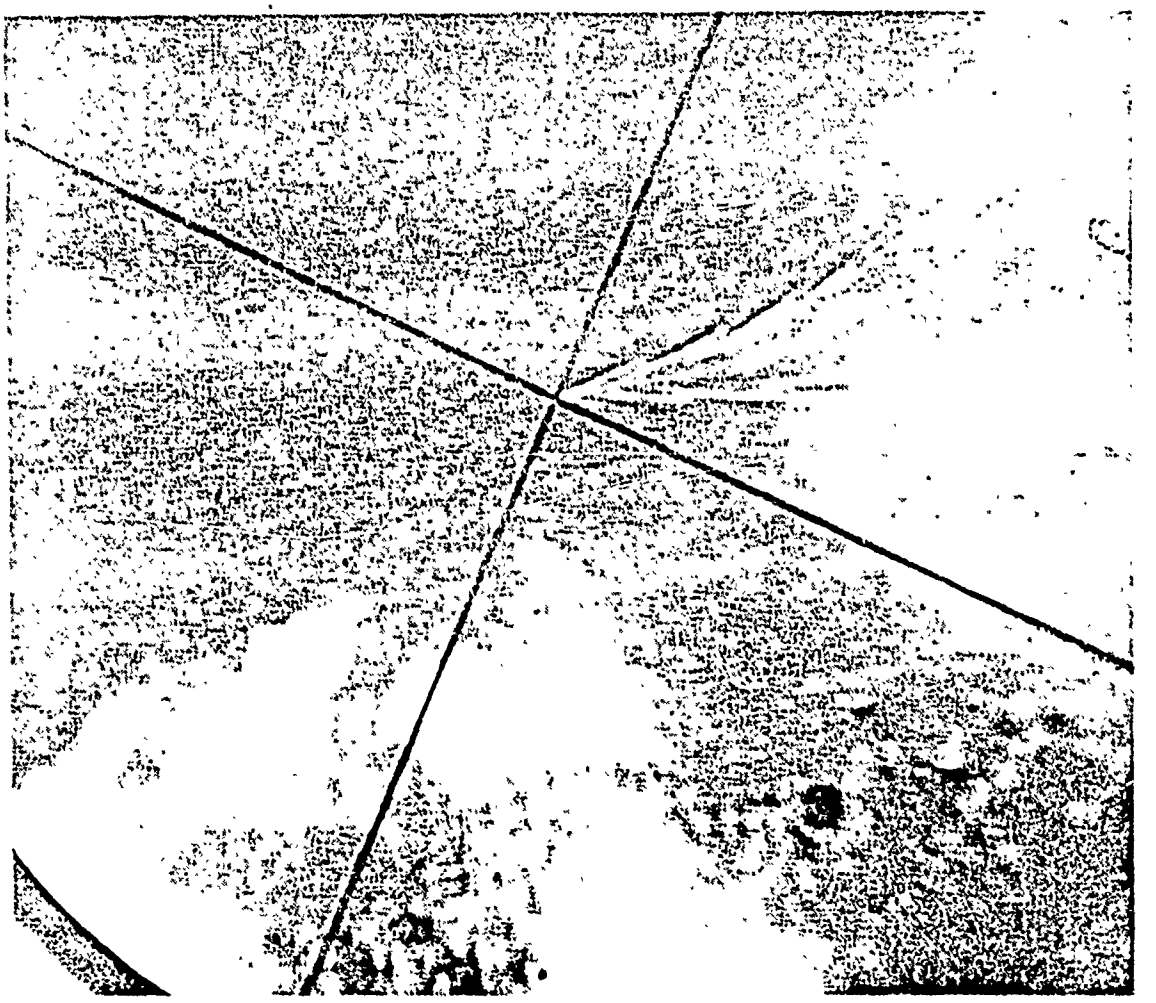
Example of boat with shape not well defined.

02
Target location in river questionable - this occurs when a target such as a boat appears to be of a certain type; but its location in the river makes the interpreter unsure of his interpretation. For example, a boat appearing like a towboat beached among a group of open-hulled craft would be unreasonable.

03
Target cut by frame boundary - this condition occurs when only part of the target is inside the boundary of the frame. Sometimes enough of the target can be seen to allow an identification of the target. Other times, the identification of the target is questionable.

04

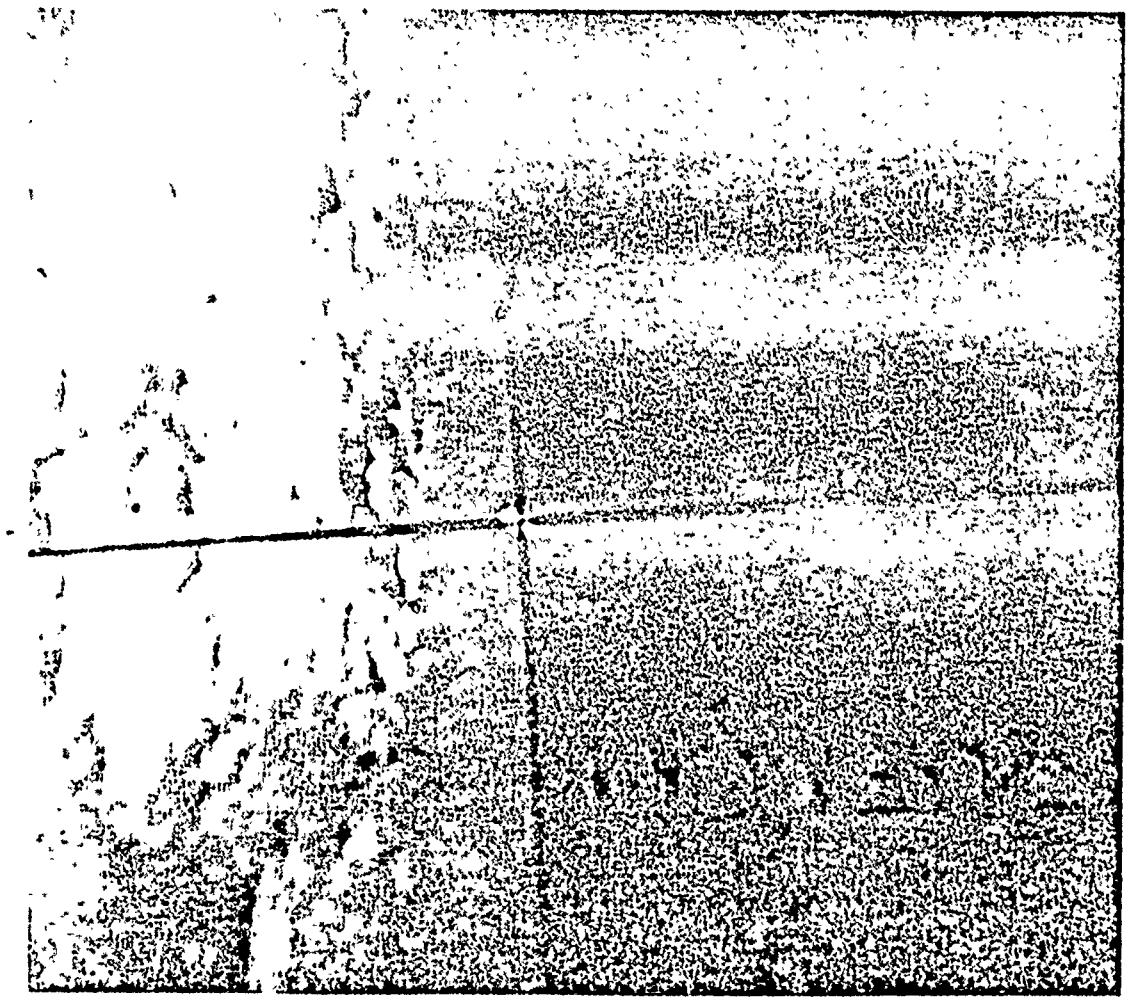
Target obscured by cloud cover - this condition occurs when low level clouds mask part of the craft.



Example of cloud cover as seen through the Bausch and Lomb Stereoscope. Digitizing cursor present.

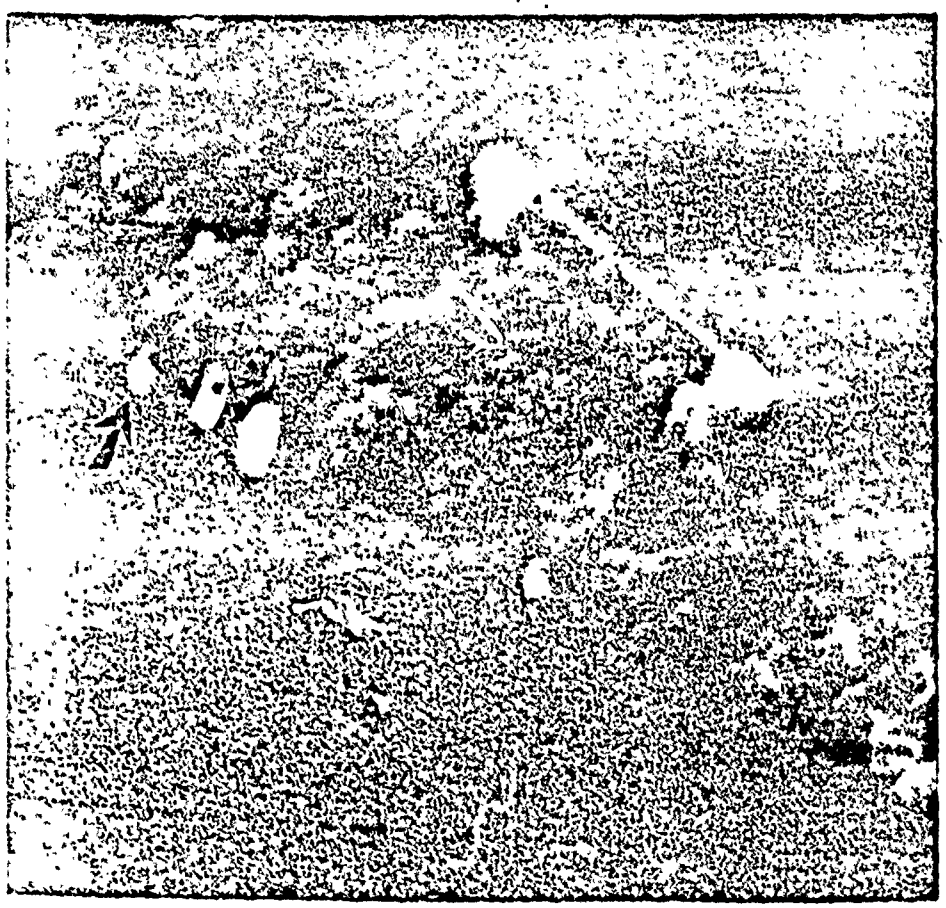
05

Target obscured by cloud shadow - this condition appears on the imagery as dark blotches on the ground. Usually, the clouds can be seen on the imagery that are responsible for casting the shadows.



Example of cloud shadow in imagery. Digitizing cursor present.

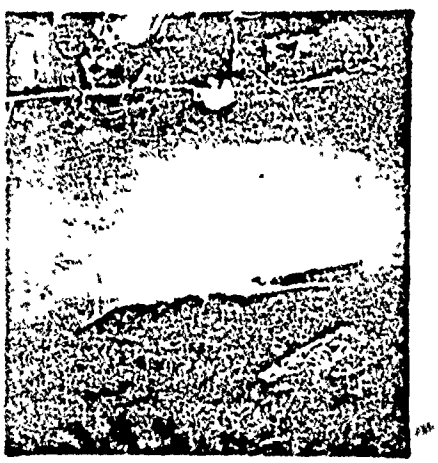
Target hidden by tree canopy - this occurs when targets are very close to or are adjacent to the shore. The tree cover masks part of the target making interpretation difficult.



Example of craft hidden by tree canopy, 30x enlargement.

07

Glare - glare is caused by the reflection of the sun on the water. Relatively large areas of the water may show glare.



Example of image with glare.

08
General underexposure of imagery - the film is darker than usual when this occurs.

09
General overexposure of imagery - the film is lighter than usual. This can make features on targets difficult to classify because the outline of decks, cockpits, seats, and masts are obscured.

SECOND REASON FOR UNSURE TARGET CLASSIFICATION WHY2

File Specification	Field width	Card No.	Column No.
Original file	2	4	51-52
SPSS file	2	3	54-55

Possible values:	Value
Shape not well-defined	01
Location in river questionable	02
Craft cut by frame boundary	03
Craft obscured by cloud cover	04
Craft obscured by cloud shadow	05
Craft hidden by tree canopy	06
Glare	07
General underexposure of imagery	08
General overexposure of imagery	09

Null values: not applicable -9

Refer to the description of WHY1 for an explanation of the codes shown above.

THIRD REASON FOR UNSURE CLASSIFICATION WHY3

File Specification	Field width	Card No.	Column No.
Original file	2	4	53-54
SPSS file	2	3	56-57

Possible values:	Value
Shape not well-defined	01
Location in river questionable	02
Craft cut by frame boundary	03
Craft obscured by cloud cover	04
Craft obscured by cloud shadow	05
Craft hidden by tree canopy	06
Glare	07
General underexposure of imagery	08
General overexposure of imagery	09

Null values: not applicable -9

Refer to WHY1 for an explanation of the codes above.

FOURTH REASON FOR UNSURE CLASSIFICATION WHY4

File Specification	Field width	Card No.	Column No.
Original file	2	4	55-56
SPSS file	2	3	58-59

Possible values:	Value
Shape not well-defined	01
Location in river questionable	02
Craft cut by frame boundary	03
Craft obscured by cloud cover	04
Craft obscured by cloud shadow	05
Craft hidden by tree canopy	06
Glare	07
General underexposure of imagery	08
General overexposure of imagery	09

Null values: not applicable -9

Refer to WHY1 for an explanation of the codes above.

BEACHING SITE - DEVELOPMENT OF THE BEACHING SITE BCHDEV

File Specification	Field width	Card No.	Column No.
Original file	2	4	25-26
SPSS file	2	3	72-73

Possible values:	Value
No development visible from beaching site	00
Some development visible from beaching site	

Null values: not applicable -9

This variable measures the amount of man induced change visible from the beached boat. The value 01 (area exhibiting some development) is defined according to whether the interpreter thinks development is visible from the beaching site. The development can take the form of houses, mowed lawns, roads, and other man-made structures. The rules for encoding this variable are not very sound at the present. This is because the interpreter is trying to judge what people at the beaching site would be able to see from their beached boat. This cannot be done very well through a photographic interpretation. An improvement would be to measure the distance a man-made change is from the beached boat.

BCHDEV

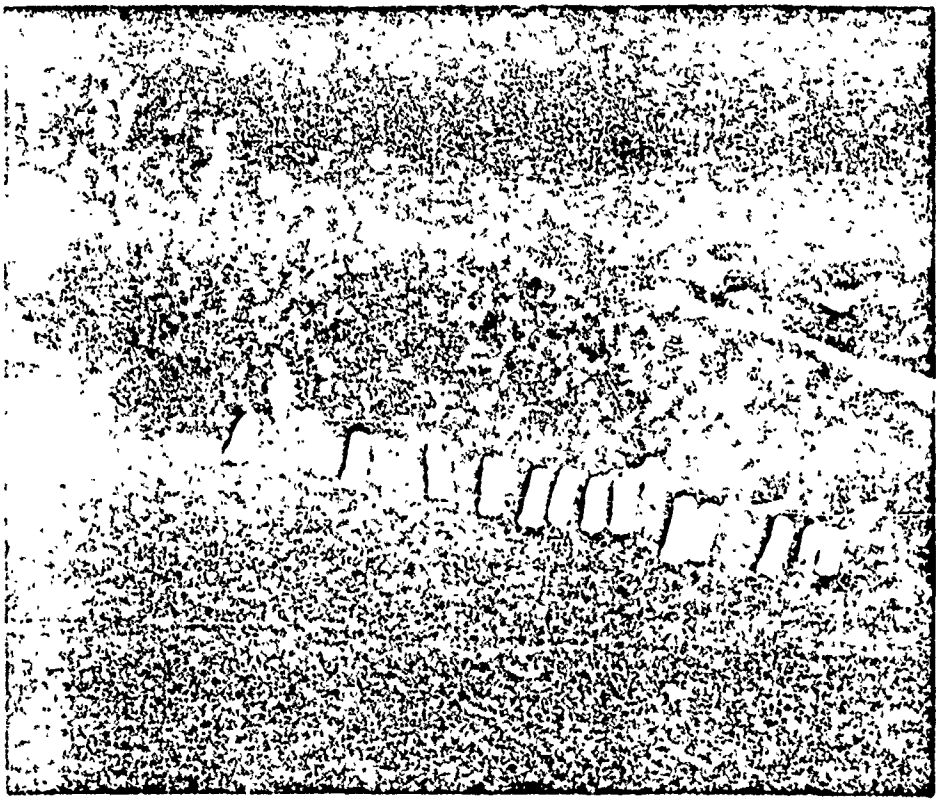
00
No Development



Frame including beaching site with no development.

BCHDEV

00
No Development
Enlargement



Beaching site with no development, 15x enlargement.

BCHDEV

01

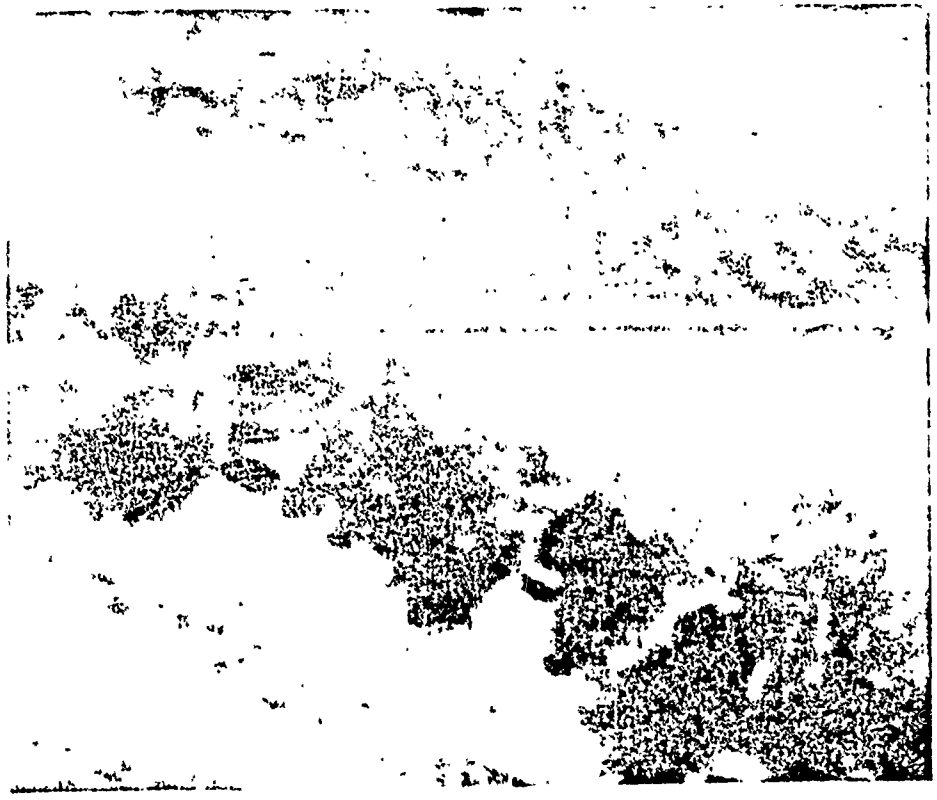
Development Present



Frame including beaching site with development present.

BCHDEV

01
Development
Enlargement



Beaching site with development present, 20x enlargement.

BEACHING SITE - LAND COVER BCHCOV

File Specification	Field width	Card No.	Column No.
Original file	2	4	27-28
SPSS file	2		74-75

Possible values:	Value
Sandy, little or no vegetation around immediate area of boat	01
Vegetated, vegetation around immediate area of boat	02

Null values: not applicable -9

Beaching site values should only be encoded for boats which are beached. A grassy lawn can be mistaken for a sandy beach, so some boats beached on grass may be included in the 01 (sandy) class.

BCHCOV

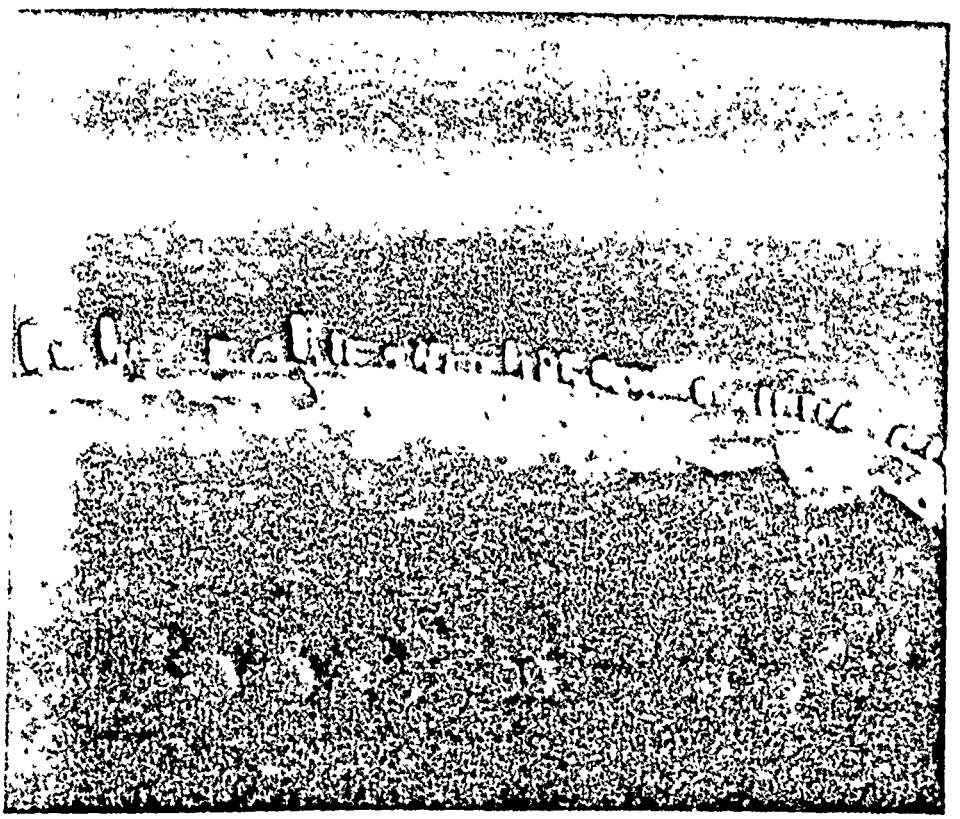
01
Sandy



Frame showing sandy beaching site.

BCHCOV

01
Sandy
Enlargement

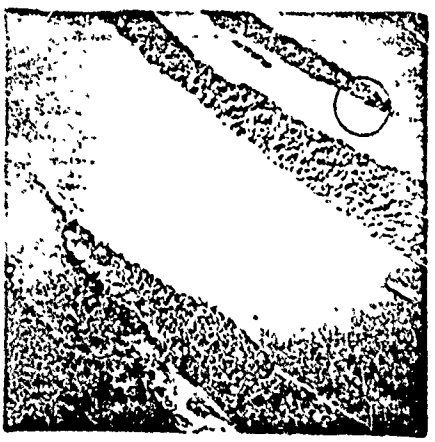


Sandy beaching site, 10x enlargement.

BCHCOV

02

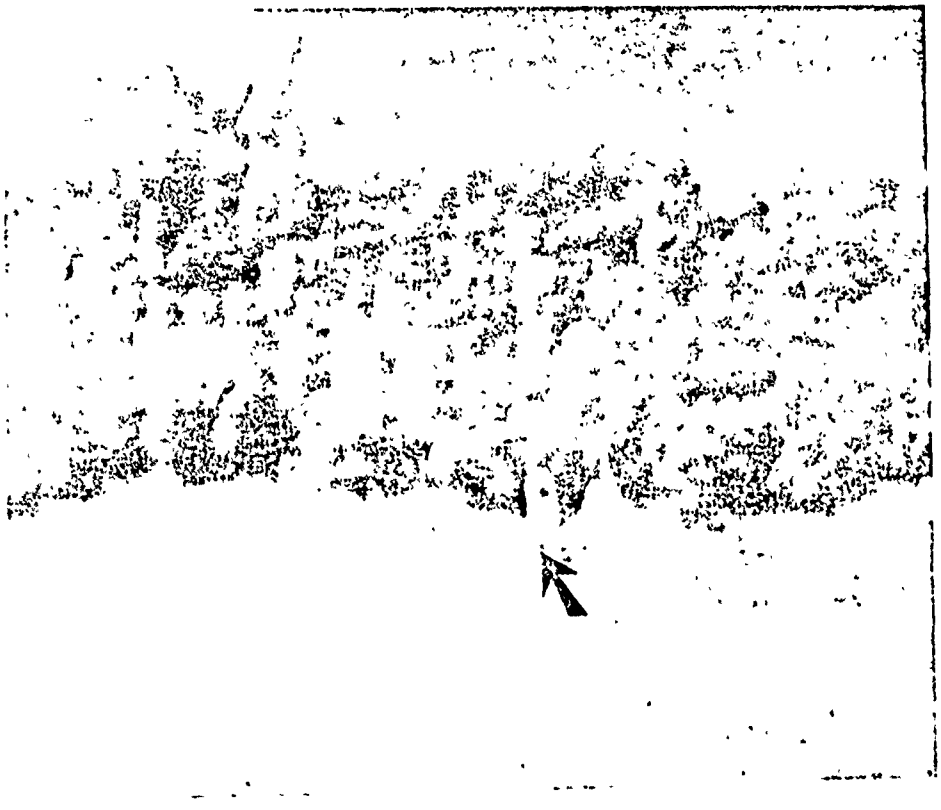
Vegetated



Frame showing vegetated beaching site.

BCHCOV

02
Vegetated
Enlargement



Vegetated beaching site, 20x enlargement.

SHORELINE - LOCATION SHORE

File Specification	Field width	Card No.	Column No.
Original file	2	4	29-30
SPSS file	2	3	76-77

Possible values:

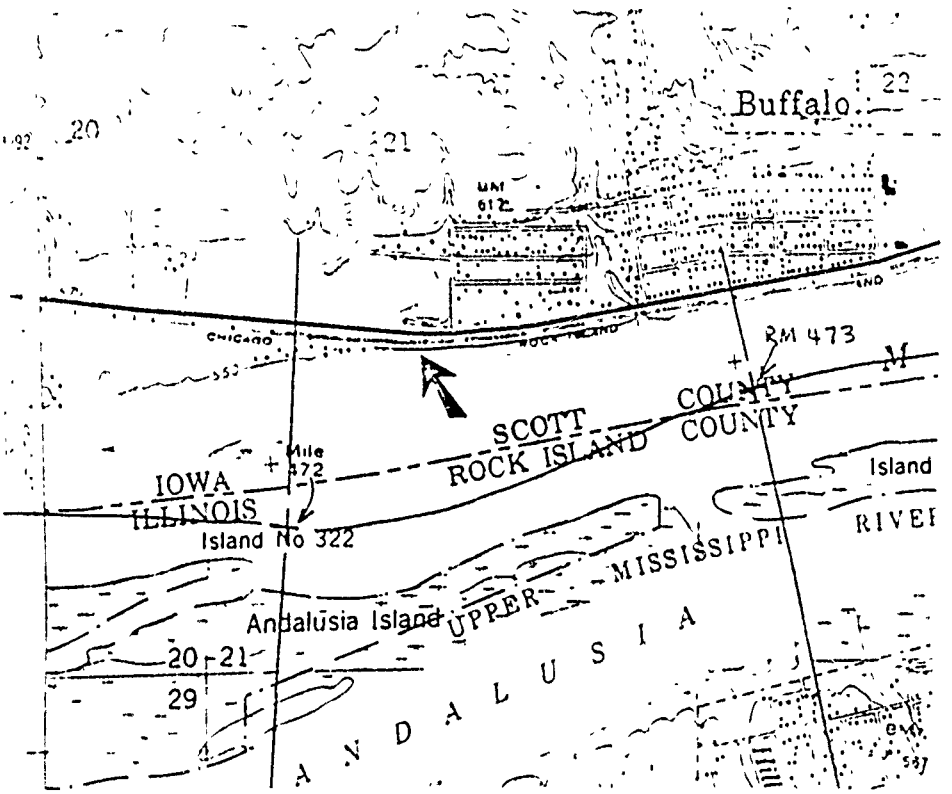
River bank shoreline, any shore that is not any island	01
Island shoreline, surrounded by water	02

Null values: not applicable -9

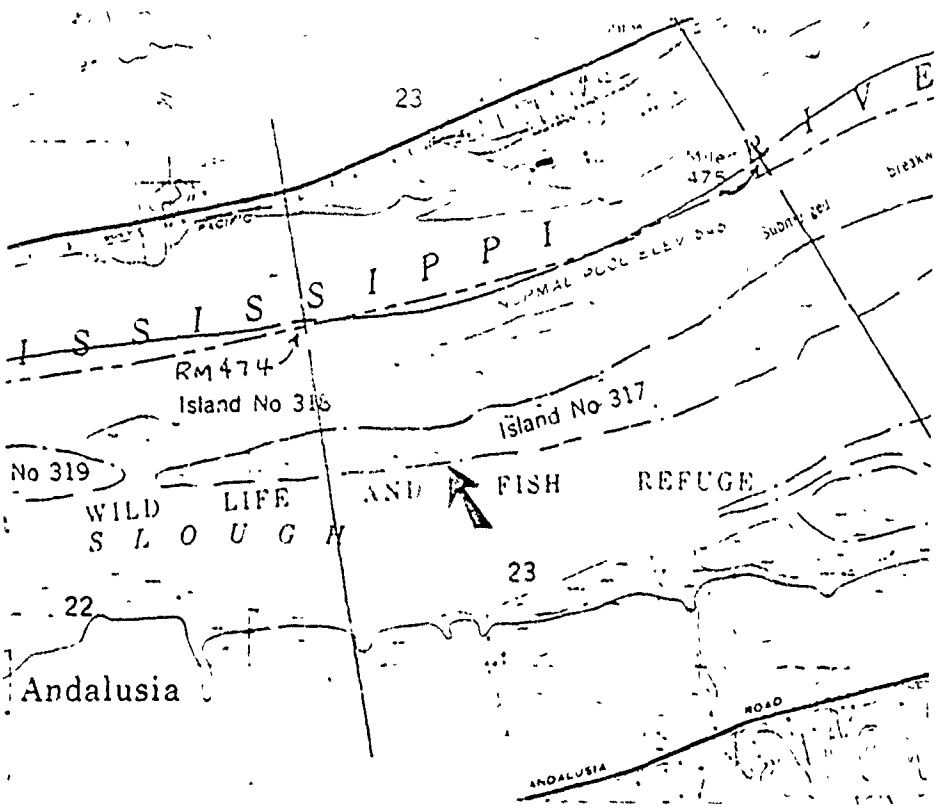
This variable applies only to docks, beached boats, docked boats, and duck blinds that are positioned on a shore of the river. Check the quad map to determine if the shoreline is that of an island. See examples of the quad map used to identify islands and shorelines.

SHORE

01
Riverbank Shore



Portion of quad map showing riverbank shore area.



Portion of quad map showing island shore are

NUMBER OF BARGES IN FORMATION NOBRGS

File Specification	Field width	Card No.	Column No.
Original file	2	4	33-34
SPSS file	2	3	62-63

Possible values: 01-24

Null values: not applicable -9

To determine the number of barges count the number in the cluster being digitized. The only target codes that should have a real value encoded for this variable are the 10 (over 1 barge only complex) and 11 (barge tow complex). See the photograph of the barge complex shown under the expanation of the target variable.

BLINDS - DECOYS OBSERVABLE DECOYS

File Specification	Field width	Card No.	Column No.
Original file	2	4	35-36
SPSS file	2	3	78-79

Possible values:

No decoys observed	01
Decoys observed	02

Null values: not applicable -9

Decoys are fake ducks that hunters spread around their duck blinds to lure the ducks within gun range. They appear as minute almost undectable, bright specks against the darker water surface, most often in a semiradial pattern around the duck blind.

Due to a miscommunication between interpreters sometimes this variable was encoded with a -9 to indicate that no decoys were observable. This is limited to pool 16, for flights on July 4, August 15, and September 15.

At the altitudes flown for this project, it is very doubtful that the photographic resolution was adequate to resolve decoys.

TYPE CHANNEL IN WHICH CRAFT IS LOCATED CHANEL

File Specification	Field width	Card No.	Column No.
Original file	2	4	37-38
SPSS file	2	3	60-61

Possible values:

Main navigation channel	01
Secondary channels	02
Backwater/inlet/bay	03

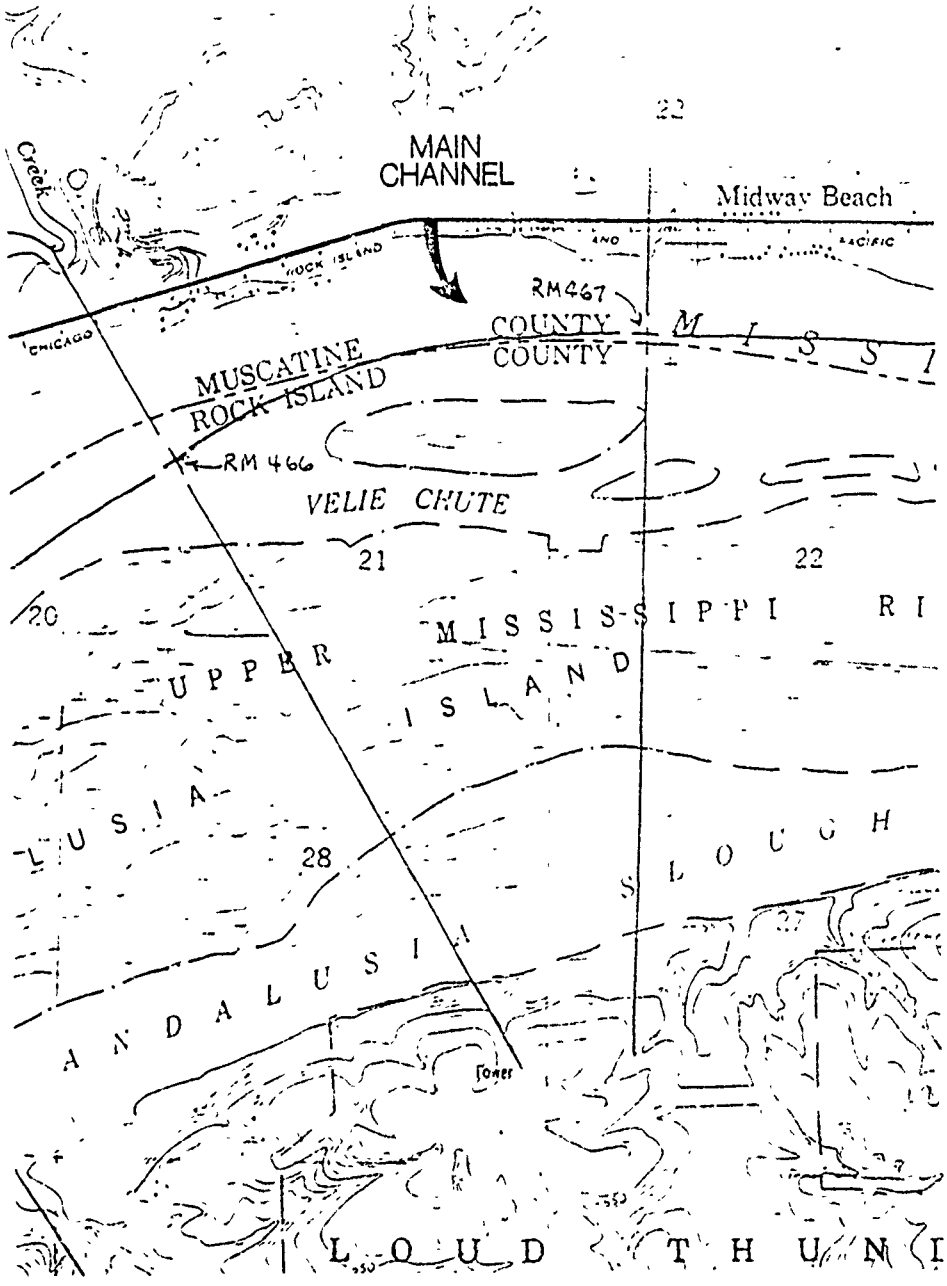
Null values: not applicable -9

The quad map is helpful in determining the proper value to encode for this variable.

CHANEL

01
Main Navigation Channel

This is determined by using the quad map. The middle of the main navigation channel has been delineated on the quad map. The source for the main navigation channel was the U.S. Corps of Engineers navigation charts.



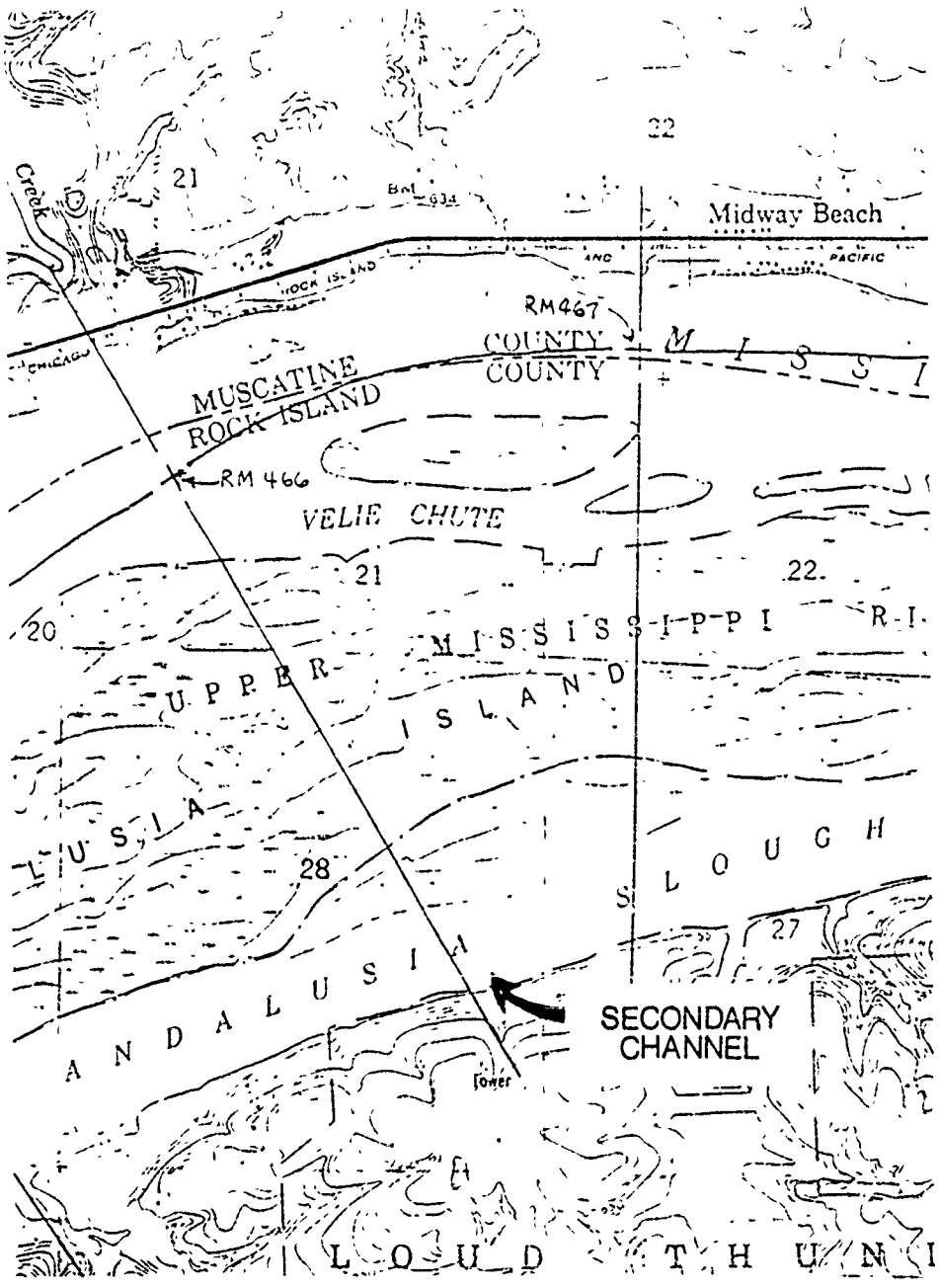
Portion of quad map containing main navigation channel.

CHANEL

02

Secondary Channels

This includes any other channel besides the main navigation channel. Secondary channels are always bounded on one side by an island.

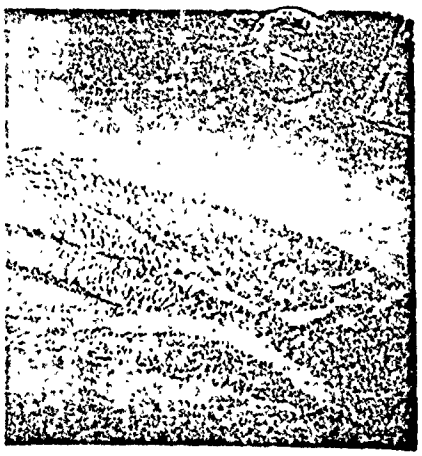


Portion of quad map with secondary channels.

CHANEL

03
Backwater/Inlet/Bay

This refers to bodies of water with only one access path. Typically they are surrounded on three sides by land. This class includes man-made embayments which contain docks and boat ramps.



Frame showing backwater, inlet/bay.

CHANEL

03
Backwater/inlet/bay
Enlargement



Backwater/inlet/bay, 15x enlargement.

WATERCRAFT ACTIVITY STATUS ACTIV

File Specifications	Field Width	Card No.	Column No.
Original file	2	4	57-58
SPSS file	2	3	64-65

Possible values:

In use	01
Beached	02
Docked at small structure	03
Docked ar large structure	04

Null values: not applicable -9

Each value will be defined below. When necessary, photos have been provided to better explain the interpretation definitions.

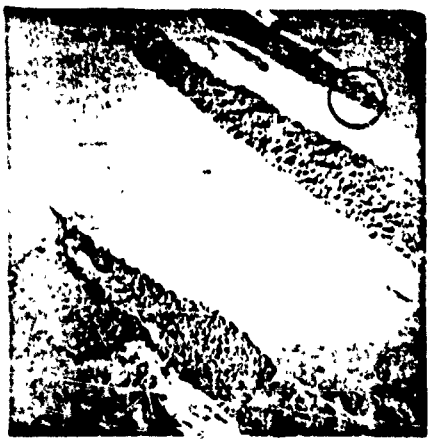
01
In Use

This value refers to boats in the water free from any shore or any dock. Boats stationary and moving in the water should be classed as being in use.

ACTIV

02
Beached

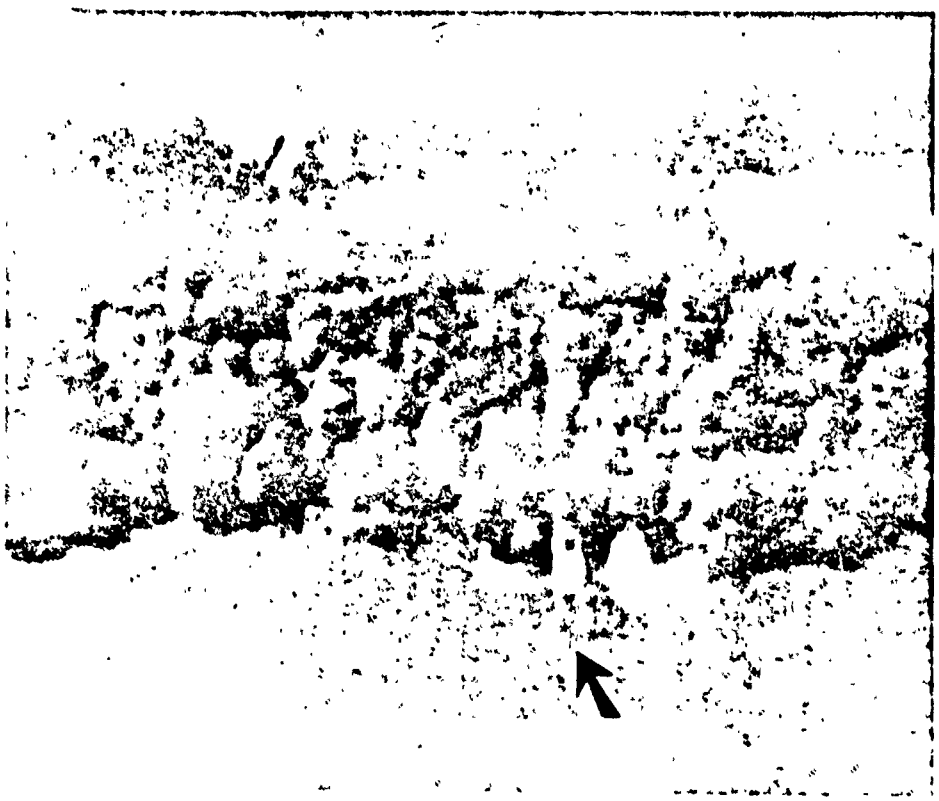
This value refers to boats with part or all of their structure on the shore, not adjacent to a dock. In some cases, barges were coded as beached when they were moored adjacent to an island. In other cases these barges were classed as idle.



Frame showing beached boats.

ACTIV

02
Beached
Enlargement



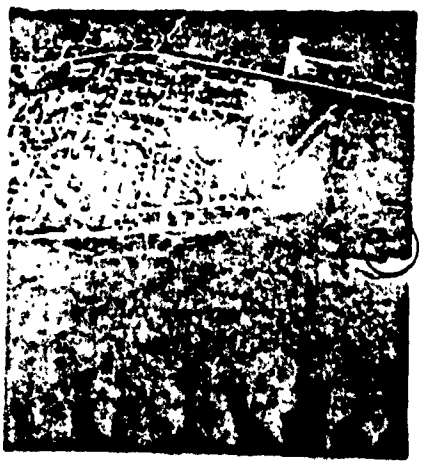
Beached boats, 20x enlargement.

ACTIV

03

Docked at small structure

This value refers to boats docked at a structure which can accommodate four or less than four boats. The determination of the number of boats that can be docked at a structure is an estimate made by the interpreter. In some cases barges were coded as being docked at a small structure.



Frames showing boats docked at a small structure.

ACTIV

03
Docked at small structure
Enlargement



Boats docked at a small structure, 30x enlargement.

ACTIV

04

Docked at large structure

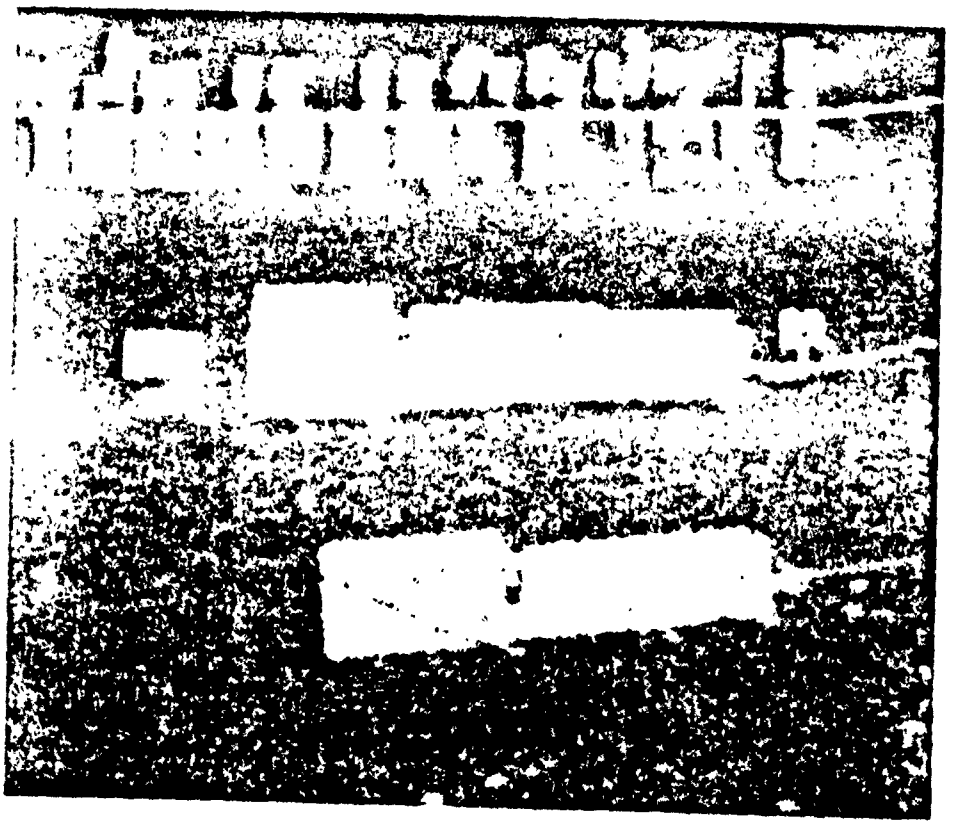
This value refers to boats docked at a structure which can accommodate over four craft. The determination of the number of boats that can be kept at the structure is an estimate by the interpreter. Barges should always be coded as 04 when they are docked. When boats are docked at marinas with many ships, the 04 code should be used to code their activity status.



Frame showing boats docked at a large structure.

ACTIV

04
Docked at large structure
Enlargement



Boats docked at large structure, 20x enlargement.

CRAFT IN USE MODUSE

File Specification	Field width	Card No.	Column No.
Original file	2	4	59-60
SPSS file	2	3	66-67

Possible values:

Underway (wake visible)	01
Idle (no wake visible)	02
Locking (in immediate proximity of lock gates)	03

Null values: not applicable -9

This variable measures the movement of boats in use. Boats docked or beached should have the not applicable (-9) value encoded. Definitions of the classes are below. When necessary, photographs have been provided to describe the interpretation definition.

01
Underway

Boats underway always show a wake. The only excention to this is in the case of a sailboat. Sails visible would signify the boat is underway.

MODUSE

02
Idle

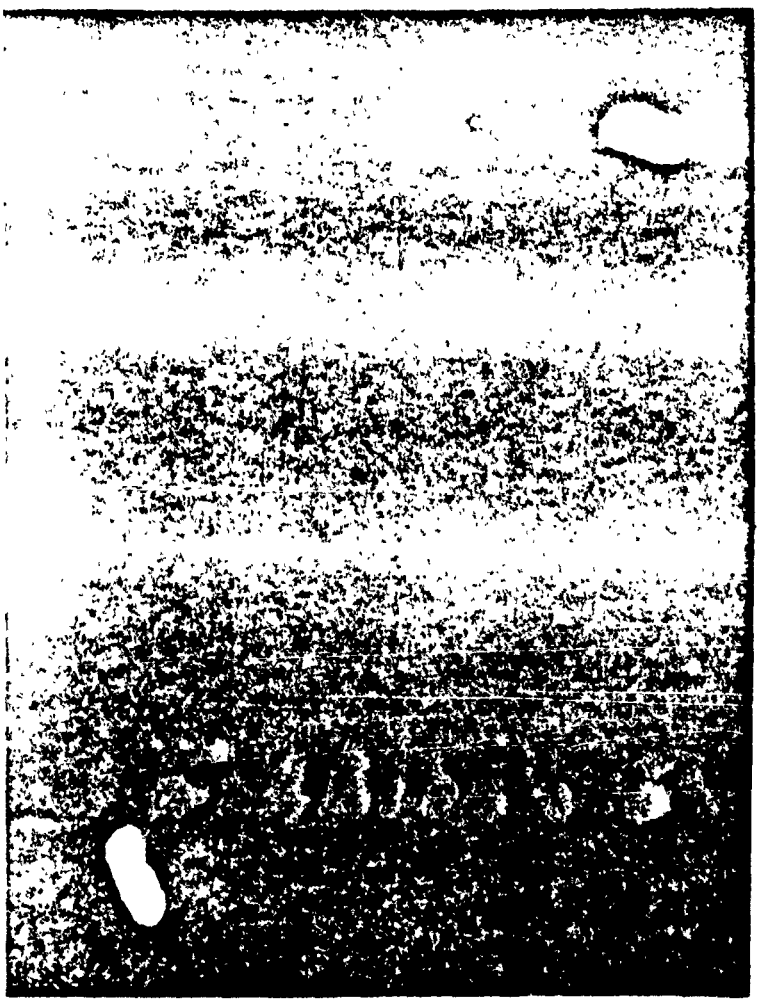
Idle boats show no wake. Clusters of barges appearing to be moored here have been given the idle value in some cases. In other cases barges moved away from a docking structure were interpreted as beached.



Frame showing idle boats.

MODUSE

02
Idle
Enlargement



Idle boats, 30x enlargement.

MODUSE

03
Locking

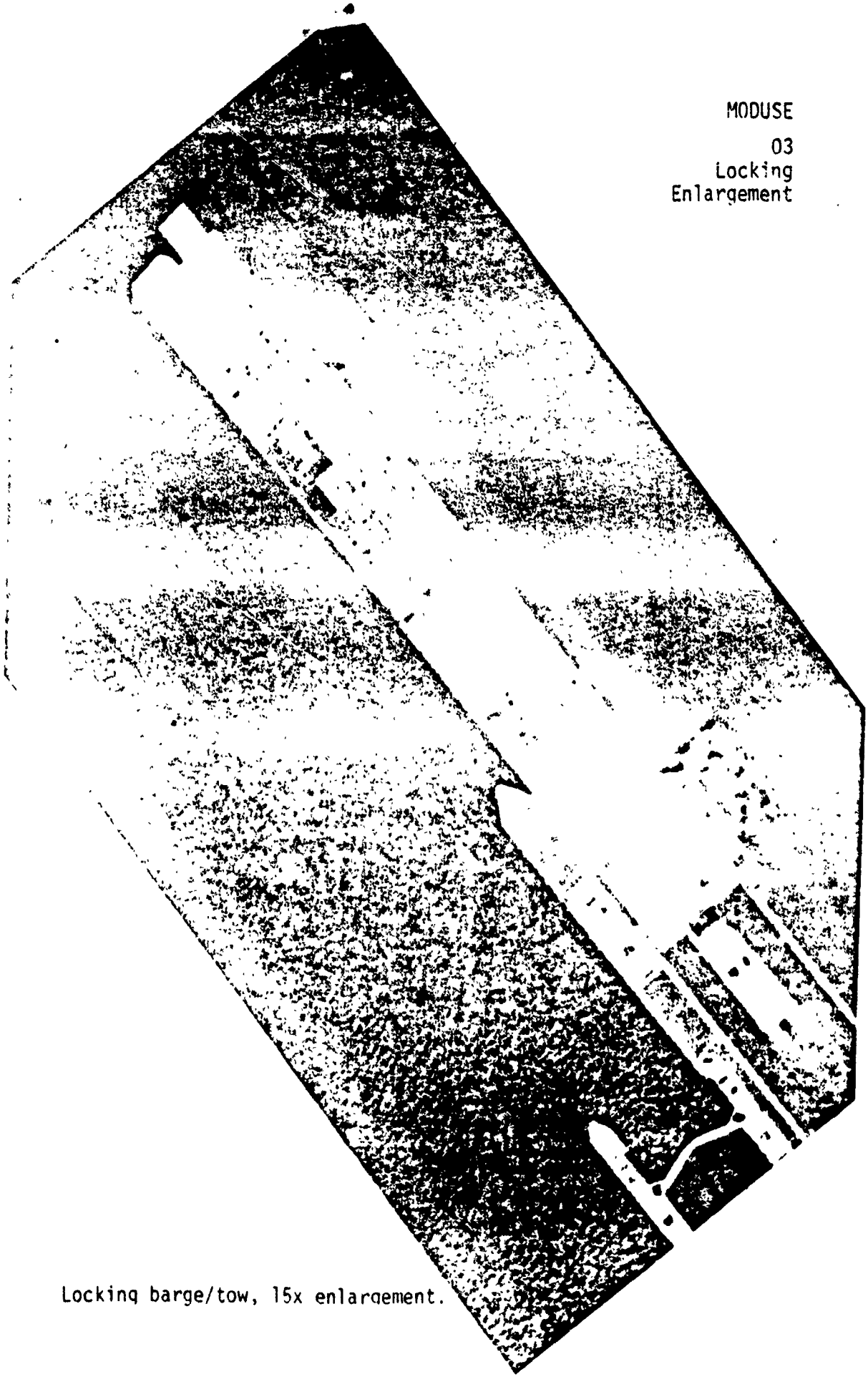
Boats located within immediate area of the lock gates should be identified as locking.



Frame showing locking barge/tow.

MODUSE

03
Locking
Enlargement



Locking barge/tow, 15x enlargement.

NUMBER OF SKIERS WITH CRAFT SKIERS

File Specification	Field width	Card No.	Column No.
Original file	2	4	61-62
SPSS file	2	3	68-69

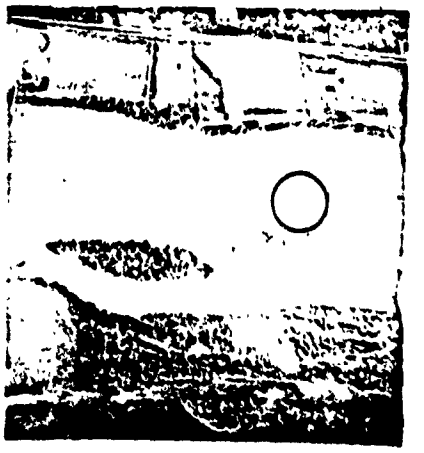
Possible values: 00-99

Null values: not applicable -9

Skiers can be distinguished by the small wake (in addition to the boat wake) trailing the skier. The number of wakes is equivalent to the number of skiers. See photograph.

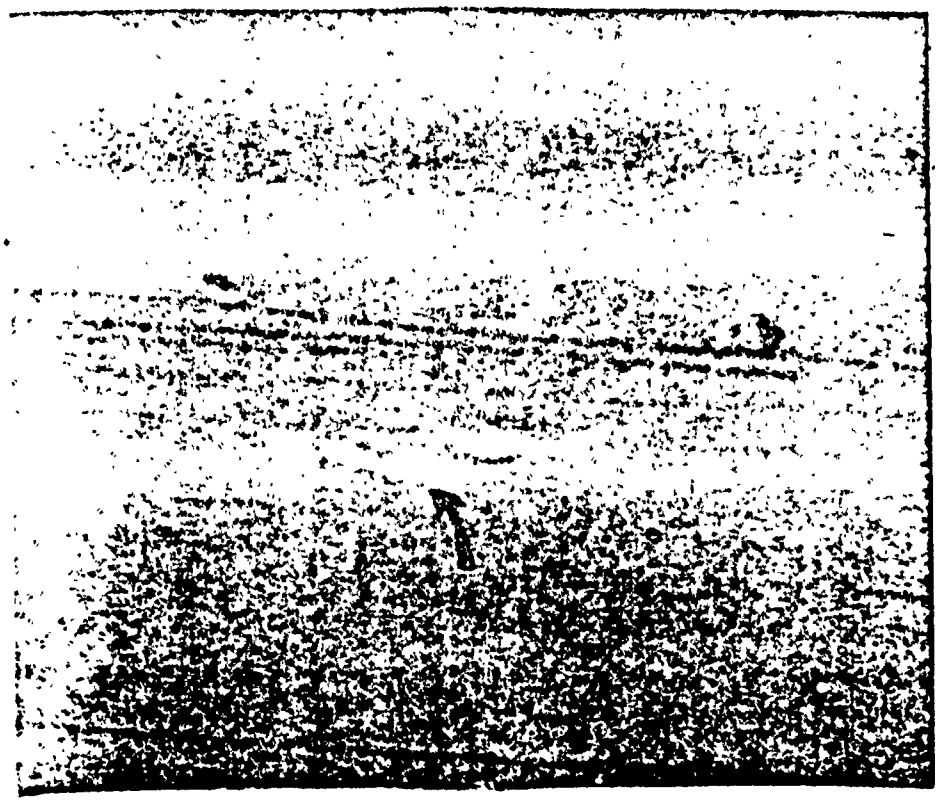
Only open-hulled boats, decked-hulled boats, and houseboats can have a value coded for skiers.

SKIERS



Frame showing one skier behind boat.

SKIERS
Enlargement



One skier behind boat, 30x enlargement.

DIRECTION OF TRAVEL DIRXTN

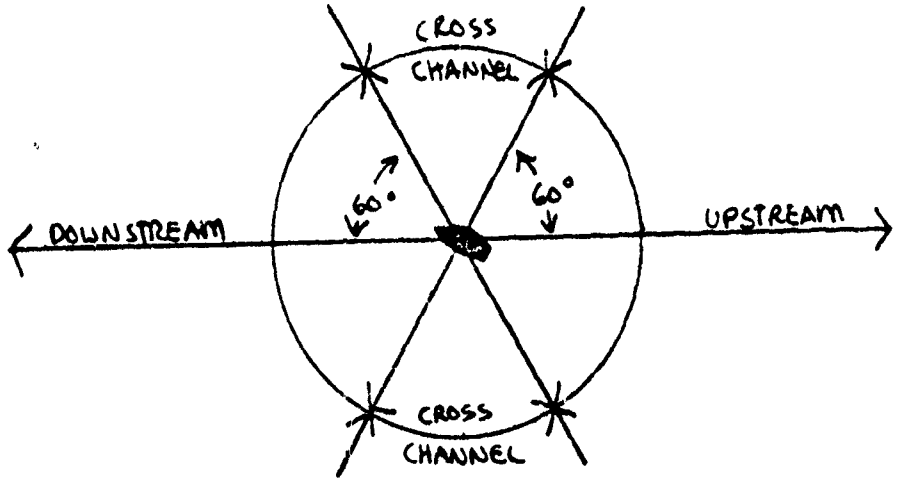
File Specification	Field width	Card No.	Column No.
Original file	2	4	63-64
SPSS file	2	3	70-71

Possible values:

Curvilinear direction	01
Cross channel	02
Upstream	03
Downstream	04

Null values: not applicable -9

Boats must be underway and in use to receive a direction value code.



Channel Direction Figure

DIRXTN

01
Curvilinear direction

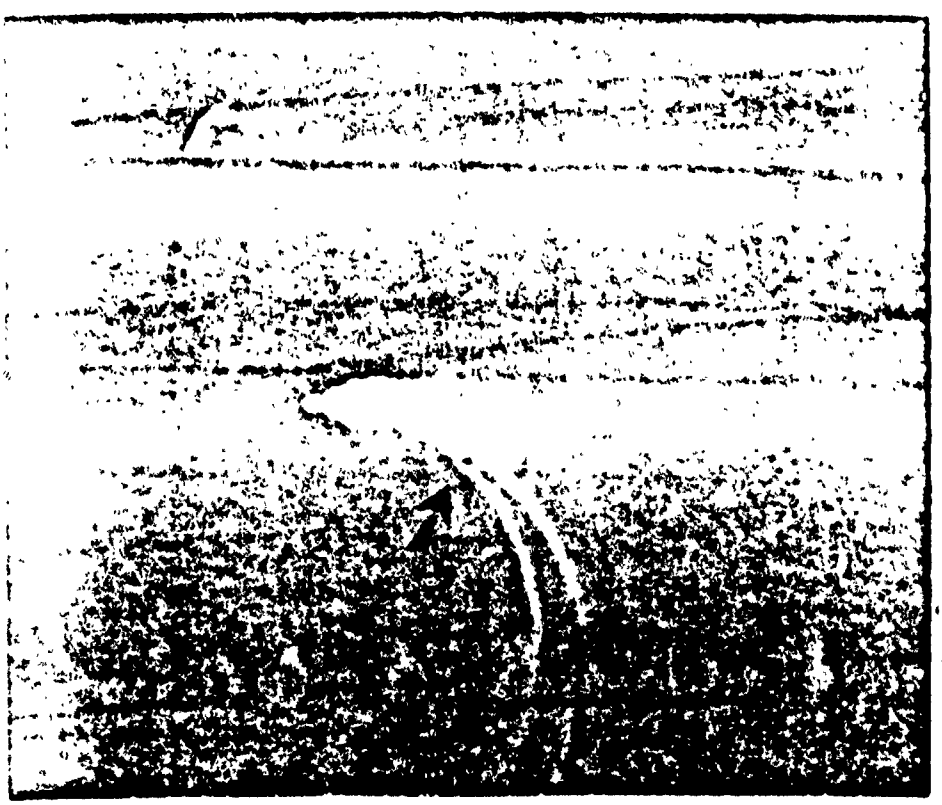
This is identified by a curved wake. See photo.



Frame showing curvilinear direction.

DIRXTN

01
Curvilinear movement
Enlargement



Curvilinear direction, 30x enlargement.

DIRXTN

02
Cross channel direction

This is identified by a boat that is headed perpendicular to the shore, moving across the channel. Refer to the photograph and the direction graph.

03
Upstream

This refers to boats moving in the upstream direction with a linear wake. Refer to channel direction figure and quad map to determine the direction.

04
Downstream

This refers to boats moving in the downstream direction with a linear wake. Refer to channel direction figure and the quad map to determine the direction.



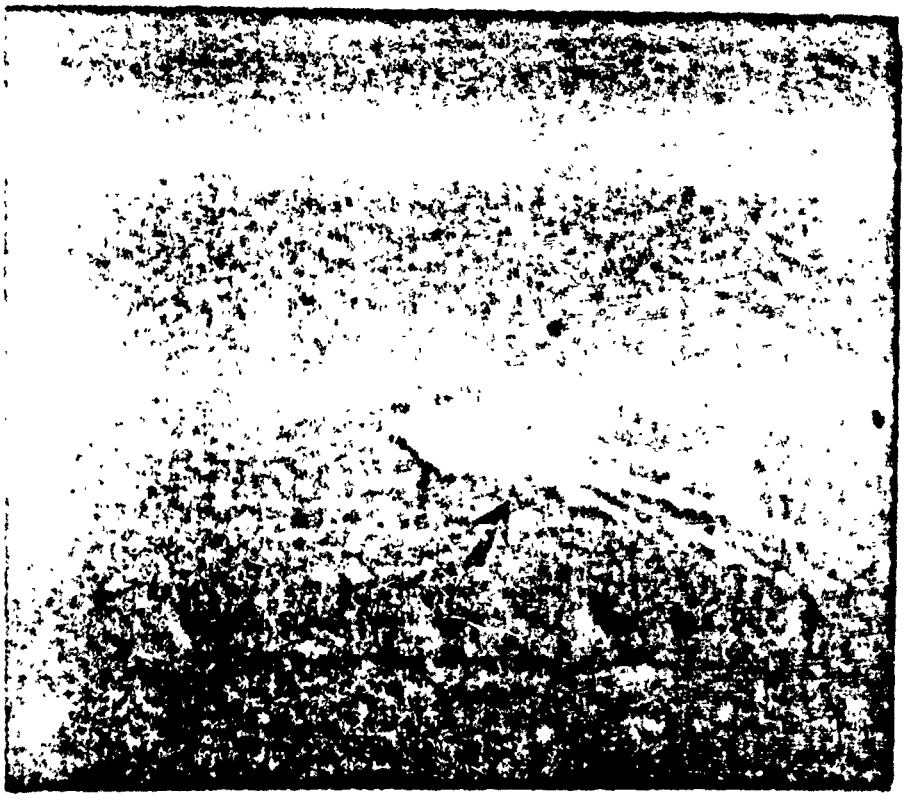
Frame showing boat with linear wake. Boats with this wake are moving either cross channel, upstream, or downstream.

DIRXTN

02
Cross Channel

03
Upstream

04
Downstream
Enlargement



with linear wake, 30x enlargement.